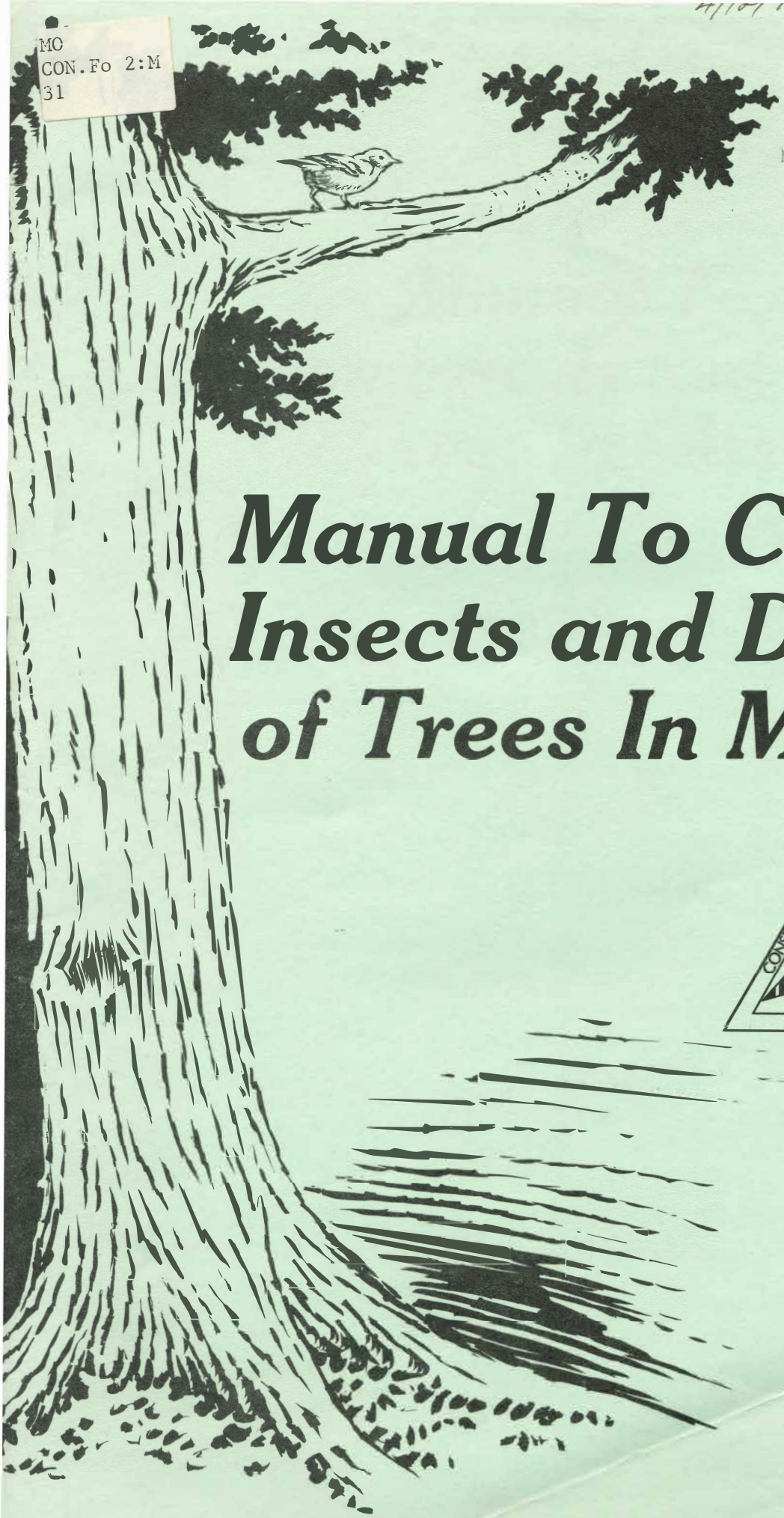

Manual To Common Insects and Diseases of Trees In Missouri

CONSERVATION DEPARTMENT
MISSOURI

Manual To Common Insects and Diseases Of Trees In Missouri

By

Ramon D. Gass
Forest Entomologist

and

Christopher J. Luley
Ph.D. Forest Pathologist

1/90

Table of Contents

Note: Certain portions of the insect text have been taken from *Insects of Eastern Forests* U.S.D.A. Forest Service. Miscellaneous Publication No. 1426 Superintendent of Documents, U.S. Government Printing Office.

Preface

There are hundreds of insects and diseases that are found in Missouri forests and urban areas. Most are harmless and some may be beneficial to man. There are relatively few which appear to or actually cause harm to shrubs or trees. It is this latter group of insects and diseases that will be treated in this pamphlet.

This pamphlet should be used as a quick reference and identification guide to the most important pest problems in Missouri. It is intended that the reader consult other more detailed sources of information for a complete description of symptoms and biology of the pest in question. A list of the most useful references on tree and shrub pest identification is given. We have also included a list of "minor" pests by host, that because of space limitations, could not be described in more detail.

Not all insects or diseases that are included in this pamphlet appear on an annual basis. Because of disease cycles or insect population fluctuation, there are times when we do not observe certain insect or disease problems. On the other hand, there are times when insect population levels are extremely high or when conditions are favorable for disease development. This is when correct control methods should be executed.

Integrated pest management (IPM) tactics can usually be employed to avoid pest problems reaching such damaging levels and can provide the most environmentally acceptable alternatives for control. IPM strategies and suggestions for monitoring individual insect and disease problems are discussed and emphasized in this manual. Arborists and other tree care individuals should be using IPM in their everyday operations.

Recommendations for chemical control of insects and diseases are presented. However, since these change frequently, it is strongly recommended that the reader make a final investigation to ensure that the present recommendations are still valid.

It should be noted that there are some insects and diseases presented here that can be found on trees or shrubs in both the forest and urban environment. Because there are crossovers in a number of situations, consult the forest and shade tree sections of this manual when trying to identify a pest problem.

Integrated Pest Management

At the start of each growing season, we encourage all foresters, arborists and Christmas tree growers to re-examine their current pest management strategies. Restrictions on the use of pesticides are becoming greater every year. Strategies have been developed to avoid, detect, and minimize pest problems, with little reliance upon chemical controls. The best known strategy is called integrated pest management (IPM).

Pest management programs using IPM should focus on (1) avoiding problems before they develop by promoting tree vigor, (2) inventory of trees being managed and periodic scouting during the growing season to identify pest problems as they develop and (3) using the most biologically and environmentally sound methods of control. Each of the three items above is a topic, possibly book-length, in itself. The basic concept involved in each, however, is very straightforward and can be readily adapted to develop an IPM program for most individual's or companies needs.

First, avoiding problems before they develop by promoting tree vigor is simply focusing on tree health to avoid pest problems. The more vigorous the tree, the more resistant it will be to insect and disease attack. Maximizing tree vigor encompasses many tree care practices, such as selecting resistant species/cultivars, matching species to the proper site, pruning, watering, staking, cabling and bracing, weed control, etc. In an urban environment, we can focus on improving the vigor of individual trees. In a forest, the emphasis is on the vigor of individual trees. Practices such as matching species and site, weed control, and timber stand improvement are useful in increasing or maintaining the health of a stand and decreasing pest problems over the long haul.

The second practice, inventory and scouting, is essential because it identifies what trees present, their condition, what problems to expect, and identifies pest problems as they develop. An initial inventory is very important because it allows one to set up scouting schedules depending on what species are present, and will also help identify trees that need additional care to improve their vigor.

Periodic scouting is crucial if pest problems are to be contained before they develop to damaging levels. Accurate diagnosis of a pest problem is essential before attempting to manage the problem. Many insect and disease problems are seen only once every few years and are new to the individual doing the scouting. Consult reference material or submit a sample to a diagnostic laboratory if the identity of any pest is in question. Scouting schedules should be designed to coincide with the development of major pest problems on tree species present at a particular location.

Control of a pest is the last step in an integrated pest management program. Certain criteria have to be met before a pesticide is considered as a control alternative. Factors including; what pest is causing the problem, the possibility of significant permanent damage to the tree, the presence of natural control agents to mitigate the outbreak, or what simple measures can be used, such as pruning or mechanical removal of the pest or affected branch, must be evaluated. If spraying is the only acceptable alternative, efforts should be made to use the most biologically effective and environmentally safe pesticide. Efforts should be made to seek out materials such as insecticidal soaps, biocontrol agents such as *Baccillus thuringiensis* (Bt, Dipel), or superior oils that are effective and present little threat to the environment.

Insecticides and other pesticides are being developed using biotechnology that are very "pest specific." All pesticides should be applied to coincide with the life stage or cycle of the pest that will give the greatest control. For the majority of pests, specific control measures have not been developed and maintaining tree vigor is the only practical management practice. And we are now back to where we started.

Arborists and other pest managers should be in the business of selling IPM as an environmentally rational approach to reducing pest problems, rather that selling pesticide sprays. As we all know, people want fast cures. It may be difficult to sell IPM when the one time call on "what can be sprayed to get rid of" is received or desired. Educating the public is a slow process, but it should be part of our task as professional pest managers to transfer our knowledge and provide the most environmentally and biologically rational pest control possible.

Forest Insects

Black Turpentine Beetle
Pine Engraver
Loblolly Pine Sawfly
Nantucket Pine Tip Moth
Pine Webworm
Redheaded Pine Sawfly
Fall Webworm
Hardwood Borers
Aphids (on Hardwoods)
Datana Caterpillars
Eastern Tent Caterpillars
Looper Complex
True Tree Grasshopper
The Twig Girdler
The Twig Pruner

Black Turpentine Beetle

Nature of Damage: The black turpentine beetle is one of the more important southern pine beetles in Missouri. It will attack stressed shortleaf trees pole size to saw-log size and kill them. The two major types of stress include, logging damage and lightning. In both cases the affected tree or trees produce resin which attract the beetle. Beetles will lay their eggs and infest the tree causing it to die.

Description of Insect and Biology: The black turpentine beetle *Dendroctonus terebrans* (Olivier), is native in the eastern United States and an important insect in Missouri. The adult is dark reddish-brown to black, and from 5 to 10 millimeters long. The head is densely granulate, roughly punctate, and convex in front. The pronotum and elytra are coarsely and shallowly punctate. Full-grown larvae are creamy white, legless, about 12 millimeters long, and have glossy reddish-brown heads.

In Missouri, the adult spends winter in forest litter. Eggs are principally laid in the basal 90 centimeters of the trunk, large roots of weakened and dying trees, and stumps of recently cut trees. Green logs may also be attacked occasionally. The female bores a hole through the bark to the cambium. Here she is joined by a male and working together, they excavate an egg gallery up to 25 centimeters wide and 50 centimeters long on the face of the sapwood, usually in a downward direction. Eggs are deposited in a long group on one side of the gallery.

The larvae feed away from the gallery in the phloem. They feed together in groups and excavate large cave-like galleries, usually somewhat fan-shaped, and occasionally up to 30 centimeters across. When fully grown they construct pupal cells either in the corky bark or between the bark and wood. The adults emerge through holes chewed through the bark and fly to trees or stumps to start a new generation. Several may emerge through a single hole. There may be two generations per year in Missouri.

Beetles are attracted to terpenes released by stumps and injured trees. Trees weakened by fire, logging, and adverse climatic conditions are highly prone to attack. Occasionally uninjured, apparently healthy trees are infested. Attacks are usually confined to a height of less than 2 meters on the trunks of standing trees. Sometimes, though they occur to a height of 3.5 meters.

Attacked trees have large reddish to whitish pitch tubes on the bark surface and whitish pitch and bark pellets in the bark crevices or at the base of the tree. Infested trees are almost always secondarily attacked by ambrosia beetles, which produce piles of fine white sawdust around the base of the tree.

Control Ethics: Where pine trees are infested in logging areas, salvage them. Caution loggers against damaging or driving close to pine not to be harvested. Where a single pine is struck by lightning, salvage as soon as possible to prevent attack and possible spread of the beetle to surrounding pines.

Chemical Control: Where saw-log size pines are used for part of a landscape they may be sprayed with Dursban if pitch tubes begin to appear. In some cases a single heavily infested tree should be removed to prevent spread to surrounding healthy pine trees.

Ips pini
Pine Engraver

Nature of Damage: *Ips pini* (Say) and others attack stressed pines in Missouri causing their final death. *I. pini* usually is associated with the black turpentine beetle in Missouri on shortleaf pine. *Ips* is primarily a secondary attacker or in a few instances can attack live healthy trees when beetle populations build from pine slash.

Description of engraver beetle: *I. pini* breeds in all species of pine and spruce within its range. Infestations usually develop in logging slash and windfalls or in trees dying of other causes. The adult is brown to black, is from 3.5 to 4.5 millimeters long, and has four teeth on each side of the declivity. The declivity is the scooped out portion of the posterior end of the body. Other southern pine engravers are *I. calligraphus, I. grandicollis,* and *I. avulsus* which produce similar galleries to *I. pini.*

Three to six egg galleries radiate away from a central nuptial chamber in the phloem, deeply scarring the sapwood. Larval tunnels extend a short distance in the inner bark and end in pupal cells. Adults remain under the bark for a short period before emerging. While there, they make irregular, meandering food tunnels, deeply engraving the wood. Winter is spent in the adult stage on the ground. There may be as many as three generations per year in Missouri.

Control Ethic: Since *Ips* is a secondary beetle of pine, it is necessary to maintain a stand in a well thinned, vigorous growing condition. Spacing should depend on the site quality. If the soil and aspect is favorable, more trees can be grown than if the soil is droughty, with a hardpan and the wrong slope aspect. Chemical spraying is not practical in a forest stand.

To protect ornamental pines, water thoroughly during dry periods and fertilize during growing season with 12-12-12. When pines are transplanted, dig a large hole to accommodate entire root system, water thoroughly, back-fill with improved soil, tap firmly and water. Build a berm around tree to catch water during dry periods. Maintain tree in vigorous growing conditions.

Loblolly Pine Sawfly

Nature of Damage: The loblolly pine sawfly *Neodiprion taedae linearis* (Ross), feeds on loblolly and shortleaf pines in Missouri. This sawfly feeds on needles, stripping twigs bare. Usually defoliation is scattered and tree mortality seldom occurs.

Description and Biology of Sawfly: Full-grown larvae are dull green and about 25 millimeters long. There are heavy black stripes along each side and often two lighter stripes below the heavier black ones. The head capsule is rusty red.

Winter is spent in the egg stage. Hatching occurs from early March to early May, depending on location. Young larvae feed gregariously in groups, often encircling the needles about half way from end to end, and partially girdling them. Infested terminals soon take on a reddened appearance.

Older larvae feed singly or in pairs and consume the entire needle, leaving short stubs on the branch. They still retain their gregarious habit, however, and move in a group from branch to branch. For the most part, they eat older foliage, but on shortleaf pine they occasionally also eat the terminal buds and tender bark on the new growth.

Full-grown larvae drop to the ground and spin mahogany-colored cocoons in the litter or topsoil. Pupation occurs in October or November and the adults emerge soon thereafter. Eggs are laid in slits cut into the needles, usually 2 to 10 per needle. Each female lays from 90 to 120 eggs, often all in the needles of one twig.

An infestation in 1972 near Salem caused heavy defoliation of shortleaf pine in that area. Parasitic wasps were responsible for the population collapse in 1972.

Control Ethic: Where only a few trees are affected, and colonies can be reached, hand strip and destroy larvae.

Chemical Control: If chemicals are required to spray large number of trees use malathion following label directions closely. Dramatic population increases and sudden collapse have been observed on shortleaf pine in south central Missouri.

Nantucket Pine Tip Moth

Nature of Damage: Terminal and lateral branch tips of Scotch, mugo, shortleaf, loblolly, jack and Virginia pines may turn brown with six to eight inches dying back.

Description of Insect: The Nantucket pine tip moth is native to Missouri. The adult's head, body, and appendages are covered with gray scales. The forewings are marked with irregular brick-red and coffee-colored patches separated by irregular bands of gray scales; the wingspread is about 12 millimeters. Though there are other closely related insects, *Rhycaionia frustrana* (Comstock) is by far the most prevalent in Missouri.

Life Cycle of Nantucket Pine Tip Moth: Winter is spent as a pupa within the injured tips of the host. Adults begin to appear on warm, sunny days in early spring. Egg laying begins in a few days, during dusk and darkness. The eggs are deposited on new or old-growth needles, in the axil of needles and stems, on developing tips, or on buds. Newly hatched larvae wander about the shoots looking for suitable feeding sites. Soon, they construct delicate webs in the axils formed by developing needles and stems.

Then the larva bores into a needle sheath and feeds on the needle, which is severed. Second instars spin new and larger webs between buds and needles and feed in the buds. When a bud is consumed, the larva moves to another bud on the same or a different shoot. Eventually, the connective tissue of the tip is severed, and the damaged portion turns brown. The larva continues to feed within the shoot and bud.

Once having consumed the bud, it bores down the center of the stem. The larval period lasts two to four weeks. Toward the end of this period, the larva constructs a webbed cell within the shoot where it pupates.

In Missouri there are three generations per year. Typically the first generation is small and the last is most noticeable by the number of brown twig tips on infested trees.

Control Ethic and Chemical Control: Damage by the Nantucket pine tip moth is least on shortleaf pine planted in the natural pine range. Damage increases as distance increases from the pine range. At least 60 species of parasites of the Nantucket pine tip moth have been recorded but they rarely provide satisfactory control.

Damage can be reduced by limiting the planting of susceptible pines to sites to which they are well adapted. Although there is little market for intermediate pine thinning (1989) close spacing and planting under an over story may also be helpful. Once shortleaf pines have grown beyond 6 feet tall they are seldom attacked by the tip moth. Where infestation affects only a few trees, the tips can be removed by July 1 and new buds will form.

In a plantation where thousands of shortleaf or Scotch pine trees might be infested, chemical control may be necessary. Malathion has proved effective against the Nantucket pine tip moth. Other chemicals to consider are Orthene, carbaryl or diazinon. Time applications by checking injured terminals for freshly emerged pupal skins or by the appearance of the small moths flying in and around the pine trees. A second or third spraying might be required to eliminate tip moth infestations. When spraying Scotch pine for tip moth add a miticide to the chemical to control both pests.

Pine Webworm

Nature of Damage: The pine webworm, *Tetralopha robustella* (Zeller) is native in the eastern United States. In Missouri it is most damaging to Scotch and shortleaf pines. Needles are chewed and a silken web covered with frass encircles the affected twig.

Description of Insect and Biology: Adults are present from June to August and deposit their eggs on pine needles. Young larvae mine the needles; older ones live in silken tubes that extend through globular masses of brown, coarse frass webbed together by strands of silk. These masses,

which are found on the twigs, enclose the needles upon which the larvae feed, and range in length from about 8 to 13 centimeters. Pupation occurs in a cell in the soil. There is one generation per year in Missouri.

Control Ethic and Chemical Control: Where only a few trees are affected in a plantation, hand pick and destroy larvae in webs. For ornamental and forest insects, scouting is a method for discovering developing insect problems before they become serious. See "scouting" section in this manual. If chemical control is necessary spray with Sevin, malathion or Orthene when insects are first developing.

Redheaded Pine Sawfly

Nature of Damage: The redheaded pine sawfly, *Neodiprion lecontei* (Fitch), feeds on needles of shortleaf, loblolly and Scotch pines in Missouri. This sawfly defoliates needles stripping twigs bare. Usually defoliation is scattered and tree mortality seldom occurs.

Description and Biology of Sawfly: Full-grown larvae are about 20 to 30 millimeters long. The head is reddish and the body is yellowish-white, with six rows of black spots.

Pupation occurs in early spring and the adults appear in a few weeks. Eggs are deposited in the tissues of current or previous year's needles; a single female deposits up to 1,550 eggs. The larvae feed gregariously on new and old needles and also on the tender bark of young twigs. Sometimes they completely defoliate a tree, progressing from the top downward, before they reach maturity. When this happens, larvae may abandon the tree and migrate for distances of several meters in search of new foliage. Full-grown larvae drop to the ground, enter the soil, and spin tough, reddish-brown cocoons in which they become adults or spend the winter as prepupae. There are three generations per year in Missouri.

Control Ethic: Where only a few trees are affected and colonies can be reached, handstrip and destroy larvae.

Chemical Control: If chemicals are required to spray large numbers of trees use malathion, following label directions closely. The native egg parasite, *Closterocus cinctipennis* (Ashmead), and the larval parasites such as *Spathimeigenia* spp. are also effective in helping to control this sawfly.

Fall Webworm

Nature of Damage: In late summer, caterpillars envelope leaves with webbing as feeding continues. Large webs are present in crown of host plant from middle to late summer.

Description of Fall Webworm: The fall webworm, *Hyphantria cunea* (Drury), is native to Missouri. It feeds on a variety of tree species including black walnut, persimmon, hickory, eastern redbud, sycamore, boxelder and others. Larvae feed in colonies and live within the web.

Full-grown larvae are usually pale yellowish or greenish, with a broad, dusky stripe down the back and a yellowish stripe down each side. They are about 25 millimeters long. Feeding begins in July and ends in late September.

Control Ethic: Webbing and caterpillars should be poked early in its development and larvae destroyed. Very warm weather may affect egg development in late June or early July. There are certain larval parasites which affect the caterpillars.

Chemical Control: Where control is desired spray with Thuricide or Dipel. Dursban or Orthene can also be used. Check insecticide labels to make sure the host plant and insect to be controlled are listed.

Hardwood Borers

Nature of Damage: Hardwood borers as a group, ruin aesthetic appeal of hardwood trees, cause decline, branch dieback or even tree mortality. In the forest, hardwood borers are responsible for log and lumber degrade resulting in value loss.

Description of Hardwood Borers: Because the nature of infestation is similar for all borer species, they are included together here. There are a number of important borers which affect different ornmental tree species. These are the bronze birch borer, two-lined chestnut borer, lilac borer, ash borer, dogwood borer, and American plum borer on sycamore.

Borers infesting forest trees and occasionally ornamental trees are the red oak borer, carpenter worm, *Goes* sp., or white oak borer, black locust borer, the poplar and willow borer, the flat headed apple tree borer and the redheaded ash borer. Staining of the bark, irregular shaped holes, wet frass on the bark scales below gallery openings and frass extruding from the gallery entrance indicate borer presence.

Life Cycle: The life cycle of each borer varies. The carpenter worm spends three years inside a tree. The red oak borer spends two years in a tree. *Goes* sp. can spend three to five years in a tree. All borers spend most of their development in the sapwood and heartwood. Periodically, borers return to the cambium where they feed, creating feeding patches between the bark and wood. Each borer has its own characteristic biology and creates its own characteristic gallery size and shape.

Control Ethic and Chemical Prevention: The best control for hardwood borers is prevention. Hardwood trees should be planted properly and well maintained to prevent borer attack. To insure borer prevention, a spray schedule

should be initiated during the first spring after planting with a follow-up the following year.

In spring, around May 25, the main trunk of newly planted and young established hardwood trees should be sprayed with Dursban or the most recently approved insecticide, as the container label indicates. This should be followed with a second spray three weeks later. A third and final spray should be made three weeks following the second spray. The purpose of the three spray applications is to include overlapping of the egg hatch of the various borers.

Once borers have entered and created galleries in a tree trunk, the main object is to stop larval feeding. This can be accomplished by probing the gallery with a flexible wire to kill the larva inside. Spray Dursban into the opening. Finally, plug the gallery entrance with wet clay or putty and spray entire trunk with Dursban.

Site and planting considerations: The transplant shock for most newly planted trees can be very great. In order to reduce this shock and make the tree less attractive to borers (1) dig a hole large enough to accommodate the entire root system, (2) water generously during dry periods through the first two growing seasons, (3) when planting, loosen burlap or paper and sever root system with a large knife to make sure the root system has freedom to grow laterally, (4) build a berm around the newly planted tree to hold water and layer about four inches deep (it will settle) or wood chips or other mulching material, and (5) support securely with wire and rubber hose and three stakes, spaced equally and opposite each other.

Hardwood Borers in the Forest: Hardwood borers affecting Missouri's hardwood forests are the carpenter worm, red oak borer and *Goes* sp. Substantial value loss occurs as a result of the hardwood borer complex. Since chemical control of hardwood borers in Missouri forests is not feasible, other methods are available to foresters to reduce the amount of borer damage.

During the reconnaissance or cruise phase of timber management the forester can identify certain areas of heavy borer infestation. The borer infested trees are marked for removal during a sanitation sawlog or fuelwood timber sale. Certain hardwood species should be favored such as northern red oak, white oak, and shortleaf pine. These species are less favored by hardwood borers, occupy better timber sites and are more resistant to drought stress.

Black and scarlet oak are more susceptible to borer attack and drought stress and should be removed as soon as they become merchantable. They should be candidates for removal in any thinning to reduce the possibility of hardwood borer incidence. White oak and northern red oak produce large acorns and are a very desirable addition to the hardwood component of the forest stand.

Where infestation is heavy, measures should be taken to identify the affected acreage and plan a clear cut, regenerating the stand to shortleaf pine by planting or direct seeding. Where forest soil is poor and borer incidence heavy, future oaks allowed to grow will also become borer infested.

Where shortleaf pine does not grow naturally, oak stands should be harvested and allowed to sprout to produce the future forest.

Aphids
(on Hardwoods)

Nature of Damage: Aphids may cause wilting and dieback of infested twigs or limbs. They may cause general decline of the entire plant. Aphids occur in colonies on a host plant and extract sap juices from the plant. Aphids may be responsible for transmitting various diseases or viruses.

Description of Aphids: Aphids, as a group, encompass many species occuring on many different species of host plants. All aphids have three protrusions called cornicles, on the posterior which separate them from other insects. They occur in many sizes and colors. All aphids produce a sweet sticky substance, called honeydew. This honeydew will mold and turn gray or black. A symbiotic relationship occurs between ants, which feed on the honeydew, and the aphids. The ants guard the aphids to ensure a continuous production of honeydew.

Control Ethics: Aphids are soft-bodied and are favorite food for lady beetle larvae and adults, aphid lions and Calosoma beetles. Sometimes aphids are called "plant lice." Before spraying an aphid infested plant, ensure that no predacious insects are present and are not already controlling the aphids.

In 1983, aphid populations were high in the state. Populations collapsed in 1984 because of heavy predation by those insects cited above.

Chemical Control: Where predacious insects are not present and control is necessary, spray foliage and twigs with Safer's Insecticidal Soap, Sevin or Malathion or diazinon.

Datana Caterpillars

Nature of Damage: *Datana caterpillars* defoliate walnut, hickory, pecan, oak and smooth sumac in Missouri.

Description of Damage: *Datanas* are gregarious and make no webs to live in. When they shed their final skins on bark surfaces some webbing is formed conforming to the trunk surface. The four major *Datanas* in Missouri are *D. ministra* (Drury), *D. angusi* (Grote and Robinson), *D. perspicua* (Grote and Robinson) and *D. integerrima* (Grote and Robinson).

All *Datanas* are native to Missouri. The yellow necked caterpillar's, *D. ministra*, food plants are varied; they include wild huckleberry, oak, maple and walnut. The adult has a

wing spread of about 50 millimeters; its forewings are cinnamon brown and are marked with irregular dark lines. Full-grown larvae are about 50 millimeters long and are moderately clothed with long soft, white hairs. The head is jet black; the prothorax, bright orange-yellow; and the body is marked longitudinally with alternate black and yellow or whitish stripes.

Adults appear during June and July. Eggs are laid in masses of 100 or more on the underside of leaves. The larvae feed in colonies near the ends of twigs and branches. When disturbed, they elevate both ends of the body. At maturity, they drop to the ground and enter the soil to depths of 5 to 10 centimeters where they pupate and spend the winter. There is one generation per year. Two species of tachinid parasites, *Compsilura concinnata* (Meigen) and *Winthemia datanae* (Townsend), are important natural enemies.

D. angusi feeds on oak and hickory and occurs throughout Missouri. The full-grown larvae resemble those of *D. ministra* but differ in having an entirely black cervical shield.

D. perspicua, the sumac *datana*, feeds on sumac in Missouri. Full-grown larvae are moderately hairy and about 50 millimeters long. The head is dark reddish to black; the cervical shield, reddish- brown; and the anal plate, blackish. The body is deep straw or lemon yellow with 11 longitudinal, dark reddish-brown to blackish stripes.

D. integerrima, the walnut caterpillar, feeds on walnut, hickory and pecan in Missouri. Adults are stout-bodied, have wing spreads of about 50 millimeters, and are clothed with dull-brown to chestnut-brown scales. The fore wings are brownish and crossed by dark, irregular lines. Full-grown larvae may attain 50 millimeters in length. The body is black with longitudinal, yellowish stripes and is covered with long, white or dirty-gray hairs.

Adults are present during spring and summer. Egg laying begins in early June, and eggs are deposited in masses on the underside of leaves. The larvae feed in colonies until almost full grown. They are often found in masses on the trunk and larger limbs where they congregate to molt. Later, they return to the foliage to continue their feeding.

Full-grown larvae drop to the ground and wander about searching for pupation sites. At this time they are often found in large numbers along the foundation walls of houses. Pupation occurs in the soil and there are one or two generations per year, depending on locality.

Control Ethic: If colonies are within reach, destroy. In landscaping, plant a variety of hardwood trees and pines lending diversity of host plants.

Chemical Control: For all *Datanas* spray colonies not within reach with Sevin (Carbaryl). Follow label directions for *Datanas*.

Eastern Tent Caterpillar

Nature of Damage: The eastern tent caterpillar, *Malacosoma americanum* (F.), is native to Missouri. Larvae feed on newly emerging leaves of eastern black cherry, wild plum and flowering crab trees, causing total defoliation. Very seldom does economic loss occur.

Description of Insect and Life Cycle: The adults are light to dark chocolate-brown, the wings are lightly dusted with white scales, and the wing spread varies from about 37 to 50 millimeter. Each forewing is crossed by two oblique white or yellowish-white lines, the hindwing is uniformly chocolate-brown and crossed by a faint white area.

Full-grown larvae have black heads, sparsely clothed with long, fine, light-brown hairs, and are marked with an apparently continuous middorsal light stripe, bordered on each side with longitudinal reddish-brown and black wavy lines. The sub dorsal area is marked with a central black area on each segment, crossed by a vertical blue mark posteriorly.

Winter is spent in the egg stage, and hatching occurs about the time the buds of the host tree begin to unfold in spring. The larvae are gregarious. As soon as they hatch, they begin the construction of a tent in a nearby trunk or branch crotch, and continue to enlarge the tent as they grow.

From this tent, the larvae crawl out to the foliage to feed. After feeding, they return to the tent to rest. When they become full grown, they leave the nest and wander in search of places to pupate. Pupation occurs in tough silken cocoons, dusted with a yellowish powder, on the bark of trees, on fences, on brush and weeds, among dead leaves and other debris on the ground, and even on the sides of buildings. When the adults appear, they lay eggs in essentially a clasping mass on small twigs or branches, or on the trunks of small trees.

Control Ethic: The eastern tent caterpillar is primarily a nuisance pest. Infested trees in parks, recreational areas, along roadsides and in the vicinity of homes may be disfigured. During most years, the eastern tent caterpillar is controlled satisfactorily by its natural enemies. Egg parasites may account for one-quarter of the exposed eggs, but only one percent of the spumaline-covered eggs. An effective method of control on isolated trees is to prune off and burn twigs containing egg masses. Destroying larval tents, preferably when the tents are still small, is also effective.

Chemical Control: *Bacillus thuringiensis* and Sevin are effective in controlling the larvae.

Looper Complex

Nature of Damage: A group of insect larvae feeding on different hardwood tree species simultaneously causes severe, unsightly defoliation.

Description of Insects and Biology: Since there are a number of different insect species feeding simultaneously, the term looper complex is used. Included in this complex

are the leaf roller, leaf tier, elm span worm, spring canker worm, linden looper and *Acrobasis* (a bud miner of walnut and hickory). All have similar life cycles and caterpillars feed during the same period in spring on different hardwood species.

Control Ethic: Looper complex populations fluctuate greatly between one year and the next. After a heavy defoliation, populations usually require 3 to 6 years to build. Defoliation is usually very heavy during out break years in the St. Louis area.

The Calosoma beetle, or fiery hunter, a predator of damaging insects, can reduce caterpillar populations. These large green beetles are usually visible on the ground or on tree trunks. Other natural control factors such as egg parasites and viruses are responsible for population collapse.

Chemical Control: While chemical control is not feasible in the forest there may be a need to protect a favorite shade tree. Where protection is required, spray foliage with Dipel, Thuricide, Dimilin or Sevin while larvae are 5 millimeters long. Defoliated trees are seldom significantly stressed by this single early defoliation. Three years repeated defoliation can kill hardwoods. Mortality seldom occurs with a single defoliation. Defoliated trees grow new leaves by early June following a heavy defoliation.

Do not spray any trees that have parasites and predators to naturally control looper insects.

Springtime is the time for insects to become active. We are all anxious to see new leaves on our trees after a long, cold, bleak winter. In some years we begin seeing new leaves on our trees in spring and before they grow very large and are completely expanded, they are chewed on by a complex of caterpillars. This chewing happens on many kinds of trees and sometimes defoliation can amount to 100 percent of all the leaves on a tree.

In Missouri, insect presence is usually observed in early May and will continue until the first week of June or approximately one month. This group of insects is termed a complex since there are four or five different insect species involved and they feed on different tree species all at the same time. These insects in the adult form are tiny moths. They are all native to Missouri.

All of the above feed on expanding leaves, while Acrobasis is a bud miner on black walnut and hickory. This insect, through its mining, will destroy the new bud, causing it to abort. After the caterpillars have ceased feeding, new buds form and new leaves occur on stripped trees. Although this defoliation process does cause added stress upon the tree and causes the tree to use additional nutrients, very seldom does a defoliated tree die from the stripping.

Natural parasites and predators eventually control large populations or outbreaks of the looper complex. A common predator is the large, metallic green Calosoma beetle which can be observed traveling on trunks of a trees in search of caterpillars. These beetles are beneficial to man and should not be feared.

There is no feasible method for control of the loopers in the forest. Since the caterpillars feed upon leaf surfaces, a stomach poison should be used to spray on small ornamental trees in the yard. Since the defoliation is unsightly for a month, but the tree will recover, spraying is not recommended.

True Tree Grasshopper

Nature of Damage: The true tree grasshopper, *Dendrotettix quercus* (Packard), present in Missouri since 1967, defoliates oak, hickory, red maple and flowering dogwood. Its range has been limited to Iron, Reynolds, and Texas counties.

Description of Insect and Life Cycle: The true tree grasshopper or post oak locust has an incomplete insect development. The mature grasshopper seen in the forest beginning in early July, is white, black, yellow, blue, and red. Feeding is begun by the immatures or nymphs. Feeding ceases by August when they lay their eggs in pods at depths of 25 to 75 millimeters in the soil. There is one generation per year.

Chemical Control: There is no need to control grasshoppers in the forest.

The Twig Girdler

Nature of Damage: The twig girdler, *Oncideres cingulata*, (Say) is native in Missouri. This longhorned beetle is responsible for severing small branch ends, causing them to fall from the affected tree in late August.

Description of Beetle and Biology: The adult longhorned beetle is 15 millimeters long with antennae longer than the body. The beetle is tan to gray with minute punctures on the elytra. After mating occurs, the female produces an encircling grove around a twig where eggs have already been tucked in niches in the bark. These twigs eventually fall from the trees. The eggs overwinter in the twigs. In April the eggs hatch and larvae begin feeding between the bark and wood of the seasoning twigs. As the ivory-white, roundheaded larvae grow, they produce larger galleries and finally mine the entire twig.

In August, larvae pupate and the adults emerge to repeat this cycle. There is a one year life cycle. Tree species affected are persimmon, hickory, oak, elm and birch.

Control Ethic: Under ornamental conditions, control consists of picking twigs and destroying. This is not a significant pest under forest conditions. There are various parasitic wasps which prey on the larvae while yet in the twigs on the ground.

The Twig Pruner

Nature of Damage: The twig pruner, *Elaphidionoides villosus* (F.) breeds in the twigs and branches of living hardwoods, such as hickory and pin oak. Larvae are responsible for the pruning of twigs and branches.

Description and Biology of Pruner: Adults are slender, elongate, brown, and are from 11 to 18 millimeters long. The dorsal surface is clothed with irregular patches of fine gray hairs. There are spines on the first few joints of the antennae, and the tips of the elytra are notched and bispinose.

Eggs are deposited in slits in the bark at leaf axils near the tips of twigs and small branches in late spring. Young larvae feed beneath the bark, often consuming much of the wood toward the base of the twig. Older larvae bore down the center of the stem toward the base. Then they sever the branch by making several concentric circular cuts from the center outward to, but not including, the thin bark. These branches, from 0.5 to 5 centimeters in diameter, break and fall to the ground with larvae in them.

The ground under heavily infested trees may be literally covered with these fallen twigs and branches. The larvae return up through the fallen branches and form a cell between wads of fibrous frass where they pupate in the spring, or in the fall. There appears to be one generation per year. Heavily infested trees may be seriously damaged but are seldom killed. Shade and park trees may be so severely pruned that they lose much of their esthetic value. The presence of numerous dead twigs and branches hanging in the crown also detract from their appearance. Collecting and burning infested twigs and branches in the spring before the adults emerge should be helpful in control.

Ornamental Tree Insects

Black Vine Weevil
European Pine Sawfly
Evergreen Bagworm
Scale Insects
Spider Mites
White Pine Aphid
White Pine Bark Adelgid
American Holly Leaf Miner
(on American Holly)
Box Elder Bugs
Lace Bugs
Elm Leaf Beetle
Leaf and Stem Insect Formed Galls
Mimosa Webworm
Smaller European Elm Bark Beetle

Black Vine Weevil

Nature of Damage: The black vine weevil feeds at night by climbing up the stems and eating notches or holes in the margins of the leaves.

Description of Insect and Life Cycle: The black vine weevil, *Brachyrhinus sulcatus*, feeds on a wide variety of plants such as yew, arborvitae and rhododendron. The adult is a brownish-black, flightless weevil, from 9 to 12 millimeters long. The thorax is densely covered with rounded tubercles, each bearing a short hair, and the elytra are often speckled with white.

Winter is spent mostly in the larval stage, but also to some extent, as pupae and adults at depths of 6 to 18 inches in the soil. Adults emerge from early May to late July and are present during the remainder of the season. They hide during the day under litter.

Chemical Control: Where control is necessary, spray affected plants with Orthene. Check label directions for proper usage and mixing. Also Dycarb or Thiodan can be used.

European Pine Sawfly

Nature of Damage: Needles of mugo or Scotch pines are chewed by colonies of 20 to 40 larvae of the European pine sawfly. Partial or entire defoliation of a tree or shrub may occur.

Description of Insect: The European pine sawfly, *Neodiprion sertifer* (Geoff.), damaging stage is a larva eventually achieving a length of one inch or 18 to 25 millimeters long. The appearance of the first instar larva varies considerably from the last instar which is grayish-green from 18 to 25 millimeters long. The head is shiny black, and there is a longitudinal light stripe down the back.

Life Cycle: Sawfly eggs overwinter in the pine needle. Eggs hatch with a warming of the temperature in spring. The tiny larvae begin feeding and eventually strip entire twigs. Upon completion of feeding, larvae drop to the litter, spin a cocoon and pupate. Adults emerge late in summer, mate and females lay their eggs in needles.

Control Ethic: Handpicking of larvae is one way to control small infestations.

Chemical Control: Larvae should be sprayed when they are very small and little defoliation has occurred. Where widespread control is necessary, spray affected trees with Sevin or malathion. Diazinon can also be used. Neo-check, a virus, is available. It can be used to effectively control the European pine sawfly.

Evergreen Bagworm

Nature of Damage: Tiny bags appear on evergreens by June 15. As bags develop and increase in size through the summer they can strip the needles from pfitzer juniper, eastern redcedar and spruce. The evergreen bagworm will occasionally feed on hardwood leaves such as eastern redbud and firethorn. When evergreens are completely defoliated, they will die.

Description of Insect: Both male and female evergreen bagworms remain in their bags until they have completed their feeding. Prior to mating, the male emerges from his bag, flies to the female and mates. The female lays her eggs in the bag and dies. The eggs overwinter and remain viable in the female bag.

Control Ethic: The bagworm, *Thyridopteryx ephemeraeformis* (Haw.) should be hand picked in autumn or sprayed around June 15 or when they are very tiny.

Chemical Control: The use of Bt. in the form of Dipel or Thuricide can be used when the bags are small. Where hand picking is not feasible and a quick control is important, use Sevin, Diazinon, or Dursban. Thorough drenching of the infested plant is important.

Scale Insects

There are more than 42 species of scale insects that infest a variety of hardwood and softwood trees and shrubs. Scale insects, as a group, are harmful to their host because they extract sap from leaves, needles and twigs. Some scale insects such as the obscure are only found on pin oak limbs while the euonymus scale infests leaves and twigs of the Euonymus.

Scale insects are difficult to control once an infestation becomes heavy. Control can be achieved during two different periods of the year. A dormant oil can be applied to hardwood trees between November 25 and February 15. For scale problems on conifers, a superior dormant oil must be used during this same period.

The crawler stage of the scale can be controlled at the end of May or whenever the crawlers are observed. Once the scale has begun its feeding, it can no longer be controlled with Sevin, malathion or Orthene; several applications of dormant oil or Sevin might be required to control the scale problem.

Listed below are some of the major scale problems that have been encountered over the years.

Pine Needle Scale—*Phenacaspis pinifoliae* (Fitch) infests Scotch and mugo pines in Missouri. The mature female scale is white and about 3 millimeters long. Males are white and slender and not more than half as long as the females.

Eggs spend the winter under the dead scale covering of the female. Hatching occurs about the time the new needles appear and the newly hatched larvae crawl to green needles to feed. They become mature in early July and the new females produce batches of eggs. Offspring of this generation reach maturity by fall and lay eggs which overwinter. There are two generations per year.

Pine needle scale infestations are occasionally so heavy that infested trees present a gray, unhealthy appearance. Heavy infestations cause the needles to turn yellow and may kill parts of branches or entire young trees. Damage is particularly noticeable and troublesome on ornamental plantings in or near towns and cities. Certain species of lady beetles are important predators of pine needle scale.

Obscure scale—*Melanaspis obscura* (Comstock), is a common problem on ornamental pin oak in Missouri. The cover of the adult female is circular, slightly convex, grayish to black and has shiny black sub-central shed skins. The body of the adult female is yellow after molting but changes to dark pink. The eggs are light pink. The male cover is similar to the female cover but is smaller, oval with a subterminal shed skin. The body of the adult male is light brown.

Populations overwinter as second-instar males and females. In the spring adult females on pin oak first appear in late April, and egg deposition and hatching begin in late June. This scale infests the twigs, branches and trunk of its host. Damage involves dieback of small diameter branches with the weakening of heavily infested trees. Natural enemies include a large number of wasps, lady beetles, fungi and mites.

Pin oak trees that are stressed through drought, soil compaction, chemicals or other factors can be especially predisposed to scale infestation and eventual decline and death.

Pine Tortise Scale—*Toumeyella parvicornis* (Cockerell), occurs in Missouri on Scotch, shortleaf and various other pines. The pine tortise scale is common in natural habitats and ornamental plantings. Adult females are convex and are dark brown or black with reddish-brown or cream-colored mottling.

There may be as many as three generations per year in Missouri. In the north, the species apparently overwinters as mated females on the stems of the host. By late spring, the adult females have greatly enlarged. In early summer, each female lays 500 eggs, which hatch soon after being deposited. First instars develop into adults and mate in mid to late summer. Damage caused by the pine tortise scale can be quite severe. Injury most frequently is incurred by seedlings and saplings, but heavy infestations may also damage mature trees. Infested trees may have chlorotic needles or many dead branches. In some cases, entire trees may be killed. Normally, this soft scale is held in check by its natural enemies which include wasps, nine species of lady beetles and a pyralid moth.

Euonymus Scale—*Unaspis euonymi* (Comstock), is found wherever euonymus grows. Although it is normally found on euonymus it has been found on bittersweet, holly and pachysandra and others.

The cover of the adult female is oyster shell shaped, convex dark brown, and has yellow or brown terminal shed skins. The body of the adult female and the eggs are normally yellow or yellow-red. The male cover is elongate, white, has three longitudinal ridges, and a yellow terminal shed skin. The male is pale orange and winged.

The euonymous scale may have two or three generations per year, depending on the locality. The primary overwintering stage is the mature adult female, although immatures may also overwinter. In Ohio, first instars are present from May through June and again in late July through August. The euonymus scale can build to such heavy populations that it may cover much of the surface area of a particular host. Under such circumstances the plant will become white with male covers. Upper surfaces of leaves become spotted with yellow areas where scales are feeding on the undersurface. Natural enemies include at least seven species of parasitic wasps, one species of lady beetle, green lacewing and two mites.

Kermes Scale—*Kermes pubescens* (Bogue), is common on white and post oak in Missouri. The mature adult females are 2 to 3 millimeters in diameter and are brown with white bands. There is probably one generation per year in Missouri with the first instar overwintering.

The overwintering first instar sheds its skin about the time that leaves first appear and then it moves to the new growth. Two more molts occur by late May or early June, and eggs are laid in late June to late July. The first instars move from the new growth and settle on main branches or the trunk, where they overwinter. In the spring, the female crawlers move to new growth, incuding petiole and main leaf veins, but males remain on trunks and main branches.

This species is responsible for the cause of leaf distortion and flagging terminals of white and post oak in urban and rural areas.

Other scale species that are infrequently encountered are the oak lecanium, cottony maple scale, terrapin scale, tulip tree scale and oyster shell scale. All have their own natural parasites and predators and can be controlled using the methods cited in this paper.

Spider Mites
(Conifers)

Nature of Damage: Spider mite infestations can cause conifers such as the spruces, Scotch pine and baldcypress to take on a light, pale yellow appearance. This fine mottling is the feeding puncture of the spider mite. Close inspection of the affected needles will reveal adults (black or red dots), full or empty egg cases, nymphs, webbing or fecal material. A hand lens or microscope is helpful in identifying spider mite activity. A quick way of determining spider mite presence is by tapping a suspect twig over a sheet of white paper. If tiny reddish spots are observed crawling on the surface, spider mites are present.

Description of Spider Mite: Spider mites are very tiny and bear eight legs. They are most noticeable in early to late summer during warm dry periods on a variety of conifer species cited above.

Control Ethic: Spider mite populations fluctuate as do all insect populations. Heavy rains can sometimes control local populations. In some years, damage is very subtle. Other years, damage is very dramatic. There are times when chemical control is necessary to destroy spider mites.

Chemical Control: Where chemical control is necessary spray infested tree with Kelthane, Pentac, Aquaflow, Avid or Omite. Thorough coverage is essential especially on the underside of the needles or leaves.

White Pine Aphid

Nature of Damage: White pine aphid adults line up on new twigs, extracting sap from the plant. They produce honeydew, which attract ants and other insects. Honeydew often molds, turning a gray or black on needles and twigs.

Description of Aphid: The white pine aphid has three protuberances or cornicles on its abdomen and can be 6 millimeters long. The body of the white pine aphid, *Cinara strobi* (Fitch), is shiny dark brown with many winged forms being present in a colony.

Life Cycle: Hatching occurs in spring and wingless females produce living young which live in colonies up to 3 or 4 inches long clustered around a branch or leader. Several generations later, winged females are produced which migrate and also produce living young. Toward fall, winged males and females mate and a new crop of overwintering eggs are laid. Young trees or individual branches of large trees may be killed by heavy infestation or their growth may be seriously reduced.

Control Ethic: Before an infestation is sprayed, ensure that there are no beneficial insects such as lady beetles present.

Chemical Control: Where control is necessary, spray with Safer's Insecticidal Soap or Diazinon or malathion. Read the insecticide label before spraying any plants to make sure host plant and aphid are listed.

White Pine Bark Adelgid

Nature of Damage: Small to large patches of fluffy white material on branches and main trunk of white pine. Node (branch) area of trunk is free of infestation. Adelgids suck sap from twigs and trunk of tree. Long-time heavily infested trees will decline and die if no control measures are taken.

Description of Adelgid: The white pine bark adelgid, *Pineus strobi* (Hartig), infestation gives the infested tree a white washed appearance. It is an introduced insect from Europe. Light infestations cause little damage, but persistent and heavy infestations will cause reduced growth of the tree and may eventually lead to its death. The white pine bark adelgid has no alternate host. Adults attach themselves in one location and extract sap from the host tree.

Control Ethic: Natural forces are at work to hold populations to a low level. Where these are not present, spraying of the adelgid must be done.

Chemical Control: Where a significant level of adelgid is present, spray with Safer's Insecticidal Soap or Diazinon. Dursban also can be used. It is important to achieve wetting coverage of the infested area. Check that both the host tree and insect are listed on the insecticide label. More than one application may be necessary since this is a difficult insect to control. Spray when crawler stage is present in late May.

American Holly Leaf Miner
(On American Holly)

Nature of Damage: Serpentine mining is evident in American holly leaves. Infested leaves turn yellow and eventually drop prematurely. Heavily infested plants will be stressed.

Description of Miner: The American holly leaf miner, *Phytomyza ilicicola* (Loew), is a serious pest of American holly in the eastern United States. The adult is a small, grayish-black fly about 2.5 millimeters long. The female punctures leaves with her ovipositor and feeds on the juices exuding from the wounds. She also deposits eggs in the under surfaces of leaves in punctures made near the midrib. The larvae mine the tissues between the leaf surfaces. The winter is spent in the larval stage in the mine. Pupation occurs from early March to early April and the adults emerge from mid-May to late June.

Control Ethic: Low level infestations may not justify control.

Chemical Control: Where chemical spraying is required use malathion or diazinon beginning at the end of May with additional sprays (total of two), seven to 10 days apart. Certain soil systemics, such as Di-Syston, may prove useful.

Box Elder Bugs

Nature of Damage: Box elder bugs feed on foliage of box elder, maple and ash. The importance of the box elder bug as a pest derives from its habit of invading houses in large numbers in search of shelter.

Description of Insects: The adult *Leptocoris trivittatus* (Say), is somewhat flattish, brownish-black on top, and about 12 millimeters long. There are three, red longitudinal stripes on the thorax; the margins of the basal half of the wings are red; and the abdomen is bright red. Nymphs (immatures) are wingless, but possess wing pads and are dark toward the head. They have bright red abdomens.

Life Cycle: The winter is spent in the adult stage in dry sheltered places, such as the attics of houses. During warm winter days, they become active and emerge from hiding, only to retreat again when it turns cold. During the spring, they emerge and fly to their hosts where they deposit eggs on the leaves.

Control Ethic: The removal of leaf litter discourages the congregating of the insects. In structures, vacuum to eliminate bugs.

Chemical Control: Spraying chemicals on box elder bugs is not feasible. Safer's Insecticidal Soap is effective against box elder bugs.

Lace Bugs

Nature of Damage: Lace bugs extract sap from leaf tissue causing leaves to take on a yellowish appearance and to fall prematurely.

Description of Lace Bug: There are a number of species of the lace bug, *Corythucha* sp. In Missouri, the most noteworthy lace bugs occur on sycamore, London plane tree, walnut, Ohio buckeye, serviceberry, and horse chestnut. Leaf feeding by the nymph and adult produces a stipling effect on the leaf. All stages (i.e. egg, nymph, and adult) may be present on underneath surface of leaf. The eggs appear as small black specks while the nymph or immature closely resembles the adult lace bug.

Chemical Control: Where lace bug control is desired, use Sevin or Malathion when nymphs appear. Make an effort to achieve thorough coverage of the underside of leaves. Check to make sure the host plant and insect to be controlled are listed on the chemical label.

Elm Leaf Beetle

Nature of Damage: The elm leaf beetle skeletonizes leaves of American, Siberian and sometimes slippery elm in Missouri. Heavily infested trees have a gray-glazed appearance.

Description of Beetle: Adults of the elm leaf beetle, *Pyrrhalta luteola* (Mueller), are about 6 millimeters long and yellowish to dull green, with a black stripe along the sides of the wing covers. There is also a short, dark spot at the base of each wing cover. Full-grown larvae are dull yellow, with two rows of black spots on the dorsum (top side) and are about 12 millimeters long. The head, legs, and tubercles are black and there is a broad yellow stripe down the middle of the dorsum.

Control Ethic: Elm leaf beetle adults spend the winter in warm, dry places. They become active during warm periods in winter. There may be three generations of the beetle in Missouri per summer.

Chemical Control: Building foundations can be sprayed with Dursban to discourage elm leaf beetles and box elder bugs from crawling to hibernation sites in a house. Where control of feeding on shade trees is required spray foliage with Sevin or Orthene. Several sprays may be required to control feeding insects.

Leaf and Stem Insect and Gall

Nature of Damage: Swollen enlargements are formed on leaves and stems of various hardwood trees. These gall formations may be objectionable to the viewer, but are very seldom responsible for tree mortality. Insect galls produced, vary in color, shape, size.

Description of Plant Gall Insects: There are many species of insects that produce galls on trees. Flies, wasps, psyllid mites and others are responsible for forming galls on trees.

Life Cycle: The biology of all gall insects is very complex, making timing of spraying very critical and difficult. Galls are formed on leaves and succulent tissue in spring because the insect requires these conditions to lay its eggs. The insect lays its egg or eggs within the tissue. A chemical reaction takes place between the developing insect and the tissue which causes the characteristic gall to form.

Some of the more commonly observed galls are the maple bladder gall mite on silver maple; the succulent oak gall on pin oak; the gouty vein gall midge on both hard maple and pin oak, the oak apple gall on white or black oak; the wooly sower gall on white oak; the oak pill gall on pin oak; the petiole gall on eastern cottonwood; the gouty oak twig gall on pin or shingle oak; the numerous galls on hackberry and hickory and the willow cone gall on willow.

Control Ethic: Once the gall is formed, control is no longer possible. As a rule, it is so difficult to determine time of spraying that spraying is not recommended under most circumstances. A tree with a few galls might be protected by pruning out the galls. Leaves and other litter should be collected and destroyed in autumn.

Mimosa Webworm

Nature of Damage: Leaf tieing and defoliation are characteristic of the mimosa webworm. Leaves are tied and pressed together and turn brown. This insect will infest mimosa, honeylocust, and thornless honeylocust cultivars.

Description of Insect: The adult, *Homadaula anisocentra* (Meyrick), is a silvery gray moth with a 13 millimeters wing span. The larvae are about 16 millimeters in length and vary in color from gray to brown. The larva body has five longitudinal white stripes. The insect overwinters in the pupal stage in cocoons. The cocoons are located under scales of bark on the trunk of the host tree, or among plant refuse underneath the tree. Matting of masses of leaves may occur on one tree.

Control Ethic: Rake plant refuse from beneath all susceptible shade trees in autumn and remove from site. Certain low levels of infestation may be tolerated.

Chemical Control: If infestation levels appear to be increasing spray foliage with Dursban or Sevin when webbing is first noticed. Two spray applications may be necessary if frequent rains occur.

Sm aler European Elm Bark Beetle

Nature of Damage: The smaller European elm bark beetle is the vector of Dutch elm disease. The beetle traditionally feeds upon and infests native Amercian elm trees (usually stressed). Not only does the beetle introduce the fungus into the tree, but it also broods in the tree which ultimately girdles the tree and it dies.

Description of Insect: An infested, infected tree is usually a prime candidate for the log yard. The beetle, *Scolytus multistriatus* (Marsh), is reddish and 3 millimeters long. The underside of the posterior is concave and armed with a noticeable projection or spine on the undersurface of the abdomen.

Control Ethic: Control and slowing spread of the beetle and the disease is achieved by removing infested, infected trees as quickly as possible and destroying all infested material. This requires a coordinated effort by neighbors and adjoining communities.

Chmeical Control: A dormant application of methoxychlor should be used on stands of high value elms as a supplement to a complete sanitation program. This must be skillfully done before new growth begins in spring.

Diseases of Evergreens: Ornamentals

Rhizosphaera Needlecast
Ozone Injury
Dothistroma Needle Blight
Diplodia Tip Blight and Canker
Phomopsis Tip Blight
Kabatina Tip Blight
Cytospora Canker
Botryosphaeria Canker
Pine Wilt Disease
White Pine Root Decline

Rhizosphaera needlecast
Rhizosphaera kalkhoffii

Spruce

Symptoms: Purpling, browning and casting of needles are the main symptoms of Rhizosphaera needlecast. Current year's needles may turn yellow, then purple-brown from August to November. In most cases, symptoms develop on one year and older needles in mid to late summer, and current year needles are still symptomless. After needles turn brown they are cast from the tree, starting on lower branches. Severely affected trees are sparsely foliated having needles only on branch tips.

Scouting: Scout for new infection of spruce needles in late summer. Rhizosphaera needlecast infection can easily be confirmed by observing small black fruiting bodies projecting from stomata of affected needles. Spider mite infestation may appear similar to the needlecast and should be ruled out, although the two problems may appear together.

Management: Blue spruce is very susceptible, white spruce is occasionally affected and Norway spruce is fairly resistant to needlecast infection. Applications of chlorothalonil or Bordeaux when needles are half elongated and again when fully elongated will give control.

Ozone Injury
Ozone

White pine

Symptoms: Ozone injury symptoms on white pine are chlorotic (yellow) flecks associated with needle stomata, and browning of needle tips. Tip burn, tufting of foliage at the ends of branches, and dwarfing develop on some white pines chronically affected by ozone, and is called chlorotic dwarf.

Scouting: Elevated levels of ozone occur statewide, including rural areas. Other species, such as milkweed, blackberry, ash and grape should be checked for purple stipling of leaf tissues, typical of ozone injury, as they are indicator species. Symptoms of ozone injury develop 1-2 weeks after acute concentrations are surpassed. Elevated levels of ozone develop in July and occur periodically August through September.

Management: Avoid the use of white pine along major roadways or heavy industrial areas. Removal of chlorotic dwarf affected trees is suggested because these individuals are genetically susceptible to ozone injury and will not recover.

Dothistroma Needle Blight
Dothistroma pini

Austrian Pine, Ponderosa Pine and Mugo Pine

Symptoms: One year and older needles exhibit brown to red spots and bands which may be surrounded by a yellow border. Girdling of the needle by the fungus causes needle tips to dieback. Current year needles develop dark green or water soaked spots and bands in late summer that turn yellow to brown later in the season. Symptoms progress from lower branches up into the crown. Dropping or casting of severely affected older needles leaves branches foliated only near their tips. Severely affected trees develop extensive browning of needles in late fall and into the winter.

Scouting: Dothistroma is most severe on exposed trees and symptoms can easily be detected in early spring before sprays are necessary. Fruiting bodies of the fungus are readily evident as they push through the epidermis of the needle in the middle of spots and bands.

Management: Seed sources of Austrian and ponderosa pine vary greatly in susceptibility to Dothistroma needle blight. Copper-containing fungicides are very effective (Bordeaux, copper resin). On lightly infected trees, a single application in early June is adequate. Two applications, one in mid-May and another in mid to late June are suggested for more severe infections.

Diplodia Tip Blight and Canker
Sphaeropsis sapinea

Austrian Pine, Scotch Pine, Ponderosa Pine

Symptoms: Infection of expanding buds and shoot tips results in brown, partially developed shoots and needles on branch tips. Shoot tips initially are pale green to light brown and exude resin after spring infection. Tips turn brown later in the season, and dieback of older needles and branches occurs in years following initial infection. Infected shoot tips on Scotch pine are often resin soaked and crooked. Cankers are often associated with wounds (e.g. hail) and are common on older stems and branches on a wide range of pine species. Cankers exude copious white resin, and often contain dead needles adhered to the resin.

Scouting: Older pines that have started production of pine cones are at greatest risk for infection. Drought increases susceptibility of pines to Diplodia. Extensive dieback following drought may occur on pines with established infections. Infection usually starts on lower branches that are shaded or exposed to minimal air movement. Top dieback, however, occurs on some trees. Large (pencil point-sized) fruiting bodies in scales of mature pine cones are easily

observed on infected trees. Pines should be scouted in late-fall early winter to determine which trees will require fungicide applications in early spring.

Management: Austrian pine should be used sparingly in landscape plantings, and only in open areas where air movement is not impeded. Pruning out severely affected branches wil improve the appearance of the tree, although it may not slow the overall increase of the disease. Fungicide application of benomyl, bordeaux mix or copper resins are effective when applied at bud break and 10 to 14 days later. (Note benomyl is labeled for Diplodia control on pine, however, a special addition that has been made to the label should be in possession of the applicator.)

Phomopsis Tip Blight
Phomopsis juniperovora

Kabatina Tip Blight
Kabatina juniperi

Eastern Red Cedar and other Junipers

Symptoms: Both Phomopsis and Kabatina tip blights cause a similar tip dieback on red cedar and junipers. Tip dieback due to *Kabatina* develops in late winter-early spring as temperatures begin to warm, but before shoot growth begins. Symptoms of Phomopsis tip blight, in contrast, are associated with periods of new shoot tip growth in late spring and during the growing season when moisture conditions are adequate to support additional growth. Shoot tips affected with Kabatina blight turn yellow-brown, and then brown, when healthy foliage is greening up. Shoot tips infected by *Phomopsis* initially turn a light or pale green, then reddish-brown, and finally ashen-gray. Both diseases are restricted to small diameter shoot tips. Severe infection may extensively damage prostrate junipers, making them unsightly but seldom causing death.

Scouting: Kabatina tip blight symptoms should be scouted before growth resumes in the spring. Scouting for Phomopsis symptoms should continue into the fall, or as long as new shoot growth is present. Fruiting bodies of both fungi are often produced in lesions of affected shoot tips.

Management: No controls are known for Kabatina blight. Good insect control may reduce feeding injuries that possibly serve as infection courts. Phomopsis blight can be controlled with benomyl spray made every 14-21 days during the periods of maximum shoot growth in the spring and fall.

Cytospora Canker
Cytospora kunzei

Spruce

Symptoms: Needle browning and loss, followed by dieback of portion of or entire branches are typical of Cytospora canker. Cankers on affected branches are usually readily evident because of rough bark, and white resin that adheres to cankered areas. Branch dieback usually begins on lower branches, but dead branches may also be seen scattered throughout the crown. Cankers may develop on main stems, causing excessive resin flow and extensive branch dieback.

Scouting: Cytospora canker is associated with dieback and decline of older spruces. Branch dieback can be observed any time of year. Drought predisposes spruces to infection, and incidence and severity of the disease often increases after periods of dry weather. Blue spruce is usually the most seriously damaged by Cytospora, although white and Norway spruce, Douglas fir and white fir are also susceptible.

Management: Protective fungicides have been suggested but are not known to be effective in controlling the disease. Mulching and watering, particularly during August or extended dry periods, may help maintain the vigor of older spruces. Removal of affected branches should be done during periods of dry weather.

Botryosphaeria Canker
Botryosphaeria stevensii

Rocky Mountain Juniper
and Eastern Red Cedar

Symptoms: Dieback of entire branches that turn light to pale green, to yellow-brown and then reddish-brown are typical of Botryosphaeria canker. Extensive branch dieback may resemble winter injury on some junipers. Cankers often form at branch crotches near the main trunk. Cankers develop as elliptical, slightly sunken areas of discolored bark. Removal of bark is often necessary to identify cankers which cause a chocolate-brown discoloration of outer sapwood. Resin flow may be present on some cankered branches.

Scouting: Thorough inspection of inner stem tissues for girdling cankers is often necessary because cankers are easily overlooked when they occur at base of branches. The disease has been found only in the Kansas City area.

Management: Eastern red cedar is fairly resistant to the disease. Check all planting stock for evidence of cankers. Removal of branches before dieback becomes extensive may slow spread of the disease.

Pine Wilt Disease
Bursaphalenchus xylophilus

Introduced Pines

Symptoms: Pine wilt disease causes a rapid death of pines, mainly Scotch and Austrian pines. Symptoms initially

appear in late summer as trees turn from a pale green-yellow, to yellow-brown to brown in a period of one to three months. Most symptoms develop by late fall, however, a second wave of symptom development begins in late winter-early spring as temperatures warm.

Branches on affected trees are brittle when broken, due to a reduction in sapwood moisture and cessation of resin flow. Blue stain fungi, although not directly involved in disease development, produce blue-colored wedges in sapwood tissues when branches or stems are observed in cross section.

Scouting: Plantings of Scotch pine (15 years and greater) should be scouted annually before March to identify pine wilt killed trees. Increases in pine wilt often occur after periods of drought.

Management: Sanitation of killed trees should be carried out annually before the end of March. Affected trees should be destroyed after removal. Watering of high value ornamental trees may help slow the spread of the disease.

White Pine Root Decline
Leptographium procera

White Pine

Symptoms: Rapid needle browning and death of pole-sized white pine occurs on wet sites or sites with clay soils. Cankers are present at the soil line and can be identified by resin flow at or near the root collar, and chocolate to black discoloration under the bark at the base of the tree. Basal cankers that girdle the stem are common on newly transplanted larger white pines in landscape plantings.

Scouting: Dead trees usually appear scattered in a planting and only a few trees may die each year. Scout to identify dead and dying trees before growth resumes in the spring.

Management: Avoid planting white pine on high clay soils and remove affected trees as quickly as possible. Control of root collar weevils may slow spread of the disease.

Diseases of Deciduous Species: Ornamentals

Fireblight
Pseudomonas Blight
Winter Injury and Canker
Nectria Canker
Thyronectria Canker
Bleeding Necrosis
Wetwood or Slime Flux
Botryosphaeria Canker
Hypoxylon Canker
Alcoholic Flux
Wood Decay
Sycamore Anthracnose
Anthracnose
Actinopelte Leaf Spot
Leaf Blister
Leaf Scorch
Cedar-Apple Rust,
Cedar-Hawthorne Rust
Cedar-Quince Rust
Apple Scab
Iron Chlorosis
Dogwood Anthracnose
Dutch Elm Disease
Elm Phloem Necrosis
Oak Wilt
Verticillium Wilt
Ganoderma Root and
Butt Rot
Maple Decline

Fireblight
Erwinia amylovora

Crabapple, Cotoneaster,
and many other Roseaceae hosts

Symptoms: Fireblight, is named for the brown, to black, scorched appearance of shoots after infection. Affected branch tips are curved or "shepards crooked." Sunken black cankers develop where the bacterium reaches woody stem tissues. A tan to amber color bacterial ooze may eminate from older cankers during wet spring weather.

Scouting: Close inspection of plants 10 to 14 days after bloom for infected blossoms and spurs is necessary to identify early infections that require immediate pruning.

Management: Plant only fireblight resistant crabapple cultivars. Prune out all affected shoots as soon as they appear (see scouting) 1 foot into healthy tissue, being sure to disinfect pruning tools between cuts. Excise cankers on large stems by cutting out cankers 1 foot above and below and 3 inches on either side of the infection. Avoid heavy application of high nitrogen containing fertilizers. Zineb, copper containing fungicides and streptomycin sulfate will reduce infection levels. Apply when the first blooms start to appear and continue every three to five days until all blooms are gone.

Pseudomonas Blight
Pseudomonas syringae

Bradford and other Callery Pear

Symptoms: Symptoms are similar to fireblight, except Bradford pear is resistant to fireblight. Shoots and leaves are typically blackened on infection, and shoots may crook or curl at the tips. Elongated, black cankers often form on branches and limited dieback of branches may occur.

Scouting: Symptoms appear in late spring-early summer, particularly in years with wet spring weather.

Management: No specific management practices have been developed other than removal of affected shoots and branches.

Winter Injury and Canker
Cytospora sp.

Bradford Pear

Symptoms: Symptoms are browning and blackening of leaves, and branch dieback occur on individual branches or throughout the crown of the tree. Bark cracking, areas of red-brown to tan split bark, and rough-textured cankers are present on dying branches. Cankers are frequently enlarged by *Cytospora sp.*, and fruiting bodies evident of the fungus may be evident in dying branches.

Scouting: Dieback of branches appears in late spring-early summer. Close examination of small diameter branches in early spring (one-half inch and less) may reveal damaged bark and cambium before branch dieback ensues. Damage of larger diameter branches usually becomes evident later in the season.

Management: Planting of winter hardy flowering trees other than Bradford pear is suggested. Other varieties of callery pear may be more winter hardy. Mulching and other cultural practice may decrease moisture stress and secondary invasion by Cytospora sp. and other fungi. Pruning of affected branches may help moderately affected trees.

Nectria Canker
Nectria cinnabarnia

Many Deciduous Species

Symptoms: Cankers older than one year are round to elongate in outline, and contain concentric rings of exposed sapwood giving the canker a target appearance. Infections are usually associated with a wound, branch stub or other breach in the stem of the tree. Branch dieback may occur where the stem is girdled. Bright red to orange fruiting bodies may develop in cankers. Nectria cankers without the target-like appearance occur on some species.

Scouting: Fruiting bodies are most apparent from autumn through the spring, although symptoms are easily identified year round.

Management: Stressed trees due to poor site or environmental conditions are most susceptible to infection. Avoidance of wounding and making proper prunning cuts will help reduce potential infection sites for the fungus.

Thyronectria Canker
Thyronectria austro-americana

Honeylocust

Symptoms: Dieback of branches, and yellowing of foliage, premature defoliation and fall coloration are gross symptoms of the canker. Cankers are distinctly sunken areas in the stem, usually with a light tan to brown face, and with or without a callus ridge. Black fruiting bodies of the fungus are often evident in the cankers.

Scouting: Branch dieback and dying of affected branches is most evident during the summer months. Cankers caused by other fungi on honeylocust may appear similar and laboratory identification of fruiting bodies may be necessary.

Management: Thyronectria canker can rapidly kill stressed honeylocust. Trees in good vigor can callus off infections. Branch infections should be pruned off to reduce potential for spread. Avoidance of wounding and excessive pruning, and using good pruning techniques will reduce chances for infection. Trees planted on poor sites are more susceptible to infection.

Bleeding Necrosis
Botryosphaeria ribis

Sweet Gum

Symptoms: Cankers, that have copious bleeding from the edges and face of the infection, are characteristic of bleeding necrosis or canker. The cankers may be located anywhere on the tree, but are frequently found at the base or lower bole. Red-brown to black discoloration of sapwood occurs under the bark. The cankers may be large, with rough bark and extensive callus tissue, or may only be recognized by the bleeding from the bark. Branch dieback, and tree death occur, depending on the location of the infection and if the canter girdles the stem.

Scouting: Bleeding of cankers is usually most evident during summer months, particularly June and July.

Management: Severely affected trees should be removed and destroyed as soon as possible. Prune sweetgum during the dormant season and be sure to disinfest pruning tools frequently where the disease is a problem.

Wetwood or Slime Flux
Erwinia spp.

Elm, Oak, Cottonwood, Mulberry

Symptoms: Excessive bleeding of foul smelling, often foamy, slimy liquid from pruning wounds or other openings in the stem is typical of slime flux. Wetwood refers to moisture and chemical changes in the wood because of the bacterial infection. A large portion of oak in woodlands have wetwood. In severe cases, wilting and yellowing of leaves, and branch dieback can occur. A light tan to gray discoloration of bark is apparent where slime flux liquid dries after running down the stem. Slime flux liquid may kill turf it contacts.

Scouting: Bleeding of trees is most evident when soil moisture levels are adequate, although the gray-tan discoloration of bark can be observed at any time.

Management: Metal or plastic drain tubes may help relieve pressure and drain excess moisture. Sterilize pruning tools between cuts on wetwood affected trees.

Botryosphaeria (Dothiorella) Canker
Botryosphaeria quercuum

Oaks

Symptoms: Flagging, or dying of branches near their tips, is the most obvious symptom of the canker. Flagged branches have wilted, fully expanded brown leaves that remain on the tree. Dark, discolored bark lesions that extend into the sapwood can be found on girdled branches. If branches are not girdled, cankers with obvious callus folds develop on older branches.

Scouting: Flagging of branches throughout the crown of the tree is most obvious during summer months. Symptoms may appear similar to those caused by cicada or twig pruner insects.

Management: Trees stressed by environmental or other factors are probably more susceptible to attack. Maintaining tree vigor and pruning out affected branches should decrease the impact of the disease. The disease may be heavy on individual trees, but infection usually subsides and is seldom fatal.

Hypoxylon Canker
Hypoxylon atropunctatom

Oaks

Symptoms: Hypoxylon canker is usually recognized after oak trees or parts of a tree die and dusky brown to black appressed stroma (fungal material containing fruiting bodies) break through the bark. Colonization of outer sapwood and bark, browning of leaves, and branch death preceed fruiting body formation. Hypoxylon canker develops elongated cankers that may encompass much of the branch surface.

Scouting: Branch death due to Hypoxylon usually occurs later in the growing season. Stroma are often present year-round on affected stems.

Management: Severely affected trees should be removed and burned or destroyed, including stumps. Drought, construction injury, or other disturbance predisposes oak to infection. Vigorous, well maintained oak are the most resistant to Hypoxylon canker. Watering is probably the best defense against the disease, because oaks are often infected with the Hypoxylon fungus, yet disease development doesn't occur until drought or other stress is present.

Alcoholic Flux
Bacterial or fungal infection

Mainly Oaks

Symptoms: Shallow infection of basal injuries by unidentified microorganisms causes a flux from the base of oaks. The flux may be quite extensive and is initially clear, but may be somewhat frothy. The flux has a fermentive or alcohol odor, which distinguishes it from the foul smelling bacterial slime flux. Minimal impact on tree health is caused by the infection.

Scouting: Symptoms usually appear in mid-summer and smelling the flux is helpful in diagnosis.

Management: No control is needed. Cleaning the affected area does not seem to slow the flux.

Wood Decay
Wood decay fungi, mostly Basidiomycetes

All Hardwoods and Conifers

Symptoms: Wood Decay is seldom a cause of branch or tree death, unless failure of branches or the tree occurs due to structural weakening. Wood decay begins at a wound. Decayed wood is initially discolored and eventually turns white to light colored (white rot) or darker brown (brown rot) than sound wood.

Wood decay fungi produce many different types of decay, from spongy, stringy, pocket, to cubical textures in the decayed wood. Heart rot, which is the decay of living trees, may occur anywhere on the tree and decay a large portion of the heart and sapwood, causing trees to be hollow or unsound.

Decayed branch stubs, basal fire scars or large uncallused pruning wounds, wood decay fungi conks or fruiting bodies, and swollen punk knots and resinosis are indicators of decay. Carpenter ants are attracted to decayed wood and are excellent indicators that decay or favorable conditions for decay exist.

Scouting: Wood decay should be scouted for in the context of its impact as a contributor to hazard trees, reduction in value of timber in woodlands, and its overall impact on tree health and longevity. Scouting can be done year round, but scouting after leaf drop allows indentification of decay that is hidden by foliage.

Management: Proper pruning practices and avoiding wounding trees with lawn care equipment reduces the long term potential for wood decay. All hazard trees should be removed promptly or the hazard corrected. Hazard trees are trees with decay or structural defect in stems or branches that increases the chances that the tree will cause damage to people or property when a branch or the entire tree fails.

Development of a systematic, documented program for identification and removal of hazard trees is highly recommended for parks, and other areas where there is frequent interface between trees and people. In the forest, trees with evidence of decay should be checked for soundness and selected against in timber management and improvement practices.

Sycamore Anthracnose
Apiognomonia veneta

American Sycamore

Symptoms: Delayed leaf flush of sycamore in the spring followed by thin, sparsely foliated crowns are the most obvious symptoms. Cankers on one year and older stems, brown, blighted shoots, immature leaves, and dead, unopened buds are common in the spring on infected trees. Irregular shaped, tan to reddish-brown dead areas on leaves, which are closely associated with leaf veins, appear on mature leaves. Small, black fruiting bodies can be found in cankers, blighted shoots and along leaf veins. Dieback of sycamore may occur in years with heavy anthracnose followed by summer drought.

Scouting: Sycamore anthracnose is severe in years when average mean daily temperature is below 52F during the two week period following emergence of first leaves. Young sycamores should be checked periodically for evidence of cankers and dead shoots, preferably in the fall when infected tissues can be prunned out.

Management: Prune out affected tissues when trees are young and to maintain an open canopy for air circulation. Plant resistant cultivars of London Plane tree (e.g. "Bloodgood"). September injection of Arbotect 20 S is the only practical chemical control. This treatment can protect sycamores for up to three years.

Anthracnose
Apiognomonia, Gnomonia sp. and related genera

Walnut, Maple, Oak, Elm, Ash

Symptoms: Anthracnose refers to a general leaf blight caused by a group of related fungi that produce acervular type of fruiting bodies. Foliar infection is usually apparent as brown, to black, large and irregular-shaped, necrotic areas. Leaf veins are killed along with leaf tissue. Infection of petioles, rachi, succulent twigs and nuts occurs on some tree species. Premature defoliation and nut infection in late summer is common with walnut anthracnose; while premature leaflet drop in the spring occurs with ash anthracnose; tatter-

ing of leaves on maples develops in early summer after infected tissues break away; and extensive browning of foliage develops on oaks.

Scouting: Initial foliar symptoms appear in late May-early June. Extensive browning of leaves and leaf drop is most common in mid to late summer. Wet spring and early summer weather favor anthracnose diseases.

Management: Most anthracnose diseases do not warrant active control measures, since damage to the tree is minimal. Rake up and destroy fallen leaves in the fall of the year. Fungicides (benomyl, bordeaux mixture, zyban, zineb to mention a few) can be used in severe cases. Applications should be made to protect leaves as they initially mature and into early summer. Fungicidal control is seldom warranted.

Actinopelte Leaf Spot
Actinopelte dryina

Red Oak Group Species

Symptoms: Small, angular to nearly round brown spots are typical of *Actinopelte* infection. The spots often coalesce and, by August, cause a general blighting or browning over a large portion of oak leaves.

Scouting: Actinopelte leaf spot builds up in late July and early August in wet years.

Management: Because infection builds up late in the season, damage to the trees is minimal and the disease does not warrant active control measures.

Leaf Blister
Taphrina cuerulescens

Red Oak Group

Symptoms: Round to oblong blisters or raised areas that initially are a lighter colored green than healthy leaf tissue are typical of leaf blister. The blisters turn brown later in the season. In cool, wet springs severe infection can occur and may cause extensive necrosis of the leaf surface later in the summer.

Scouting: Leaf blister infection occurs in early spring as leaves develop and symptoms initially appear when leaves are mature. Browning of blisters occurs later in the season.

Management: Damage caused by the diseases is minimal and does not warrant active control measures.

Leaf Scorch
Xylemella fastidiosum

Elm, Oak (Red, Pin and Scarlet) Red Maple, Mulberry, Sycamore

Symptoms: Leaf scorch induced by this bacterium is not uniform on the leaf margin. Marginal browning occurs on sections of the leaf and is usually surrounded by a band of yellow or chlorotic tissue. Initially a single branch or section of the tree will exhibit symptoms, followed by progression to the entire tree. Symptoms progress from older leaves to shoot tips, and premature leaf loss, branch dieback, and decline may follow in severe cases.

Scouting: Foliar symptoms develop acutely during periods of moisture stress, usually in August and September. Leaf scorch from abiotic causes should be ruled out before the disease is suspected.

Management: Little is known about the biology or control of leaf scorch.

Cedar-Apple Rust
Cedar-Hawthorn Rust
Cedar-Quince Rust
Gymnosporangium spp.

Crabapple, Hawthorne

Symptoms: All the rust diseases cause orange to yellow spots on multiple roseaceous hosts. Severe infection causes leaf browning and defoliation during the summer. Quince rust commonly affects fruits, causes swelling and distortion of petioles and succulent twigs, cankers on older branches, and dieback of shoot tips on hawthorne. Junipers and cedars serve as alternate hosts for the rust fungi. Hawthorne and cedar-apple rust fungi produce elongated, orange tenacles from galls on alternate hosts in the spring of the year. Cedar quince rust cause perennial cankers from which orange, gelatinous spore masses eminate in the spring.

Scouting: Infection of roseaceous host occurs when orange sporn horns are apparent on juniper. Foliar symptoms develop in May as leaves mature fully in the spring.

Management: Resistant crabapple and hawthorn cultivars are suggested for new plantings. Removal of red cedar or alternate host in close proximity to susceptible roseaceous cultivars may reduce infection, however, spores from cedar can travel long distances making this practice often untenable. Fungicide sprays of Bayleton, ferbam, or chlorotholonil need to be made to protect leaves during April and May. Apply every 10 to 14 days after first galls on junipers produce spore horns in the spring.

Apple Scab
Venturia inaequalis

Apple, Crabapple, Mountain Ash

Symptoms: Infection of leaves and fruit initially appear as small, olive green spots. The spot turns smoky-brown to black, enlarge greatly, and have feathery margins. On susceptible cultivars in wet years, succulent leaves may be nearly entirely infected. On older leaves later in the season, severe infection results in extensive yellowing and leaf loss.

Scouting: Infection of leaves occurs as they emerge from buds in the spring. Symptoms appear shortly after leaves are fully expanded. Apple scab is severe in years with wet spring weather and susceptible cultivars will be nearly defoliated by mid-August.

Management: Use of resistant crabapple cultivars is highly recommended for new plantings. Clean up and destroy fallen leaves in the fall. Fungicide applications need to be made on a regular basis as leaves emerge from buds in the spring. Apply captan, benomyl, ferbam, folpet, maneb, mancozeb, chlorothalonil, zineb or zyban just before bloom and make one to three additional applications at seven to 14 day intervals.

Iron Chlorosis
Iron Deficiency

Pin Oak, Silver Maple, Sweetgum

Symptoms: Interveinal yellowing (in which the veins remain green) is typical of iron chlorosis. The degree of yellowing varies from a slight pale yellow to almost white. Leaves may also have a reddish-orange cast depending on the time of year. Individual branches, sections, or the entire tree may be chlorotic. Marginal and interveinal browning, and fungal leaf spots may develop on debilitated leaves. Severe chlorosis will result in decline, particularly on pin oak. Chlorosis due to other micronutrient, such as maganese, appear similar to iron chlorosis.

Scouting: Trees susceptible to chlorosis should be checked after leaves have fully emerged and again later in the season.

Management: Many strategies exist for treating iron chlorosis including injecting materials containing iron into the trunk, applying iron-containing materials to leaves or soil, and acidifying the soil with sulfur compounds. Combinations of treatments are usually the most successful. Soil acidification with 6 lbs/100 ft^2 of sulfur (broken into 2 to 3 applications) and foliar and soil treatments with chelated iron should provide immediate help and 3 to 4 years of extended relief from iron chlorosis. Injection of iron into tree trunks is not recommended because of the potential for long term damage to the tree from secondary invasion of injection wounds.

Dogwood Anthracnose
Discula sp.

Flowering Dogwood

Symptoms: Leaf infection appears as tan spots with purple margins. Severe infection results in large necrotic blotches on leaves. Flower bract infection is rare but occurs in wet years. Blighting of entire leaves, and progression of infection down petioles into stems results in cankers. Brown, elliptical cankers are most evident when bark is removed. Lower branch dieback, epicormic branching, and mortality occur on heavily infected trees.

Scouting: Foliar symptoms develop first on lower branches and in early summer. Blighting of entire leaves, cankers, branch dieback, epicormic branching and mortality are common in Eastern states. As of fall 1989, the disease has not been identified in Missouri but is present in west-central Tennessee.

Management: Good cultural practices will greatly reduce the impact of dogwood anthracnose. Mulching, watering during periods of drought, proper site selection (some shade is desirable for dogwood) and moderate fertilization will help maintain healthy trees. Clean up and destroy leaves in the fall. Prune dead branches during the dormant season. Remove all succulent branches on main stem to help prevent trunk canker formation. Benomyl, chlorothalonil or mancozeb, applied three to four times at two to three week intervals starting at leaf expansion, will supplement cultural control practices.

Dutch Elm Disease
Ceratocystis ulmi

American Elm

Symptoms: Dutch elm disease first appears on a tree as a yellowing, wilting and then browning on a single branch, usually near the tip. As the disease progresses, the entire branch dies and symptoms spread to adjacent branches and whole tree. Removal of the bark from affected branches will reveal a distinct, brown streaking or discoloration of sapwood.

Scouting: New infections of Dutch elm disease can be observed in early summer. Symptoms on trees with carry-over infection from previous years appear as leaves mature in the spring. Scouting for new infections is important if therapeutic treatments are available.

Management: Asiatic elms, such as chinese elm, are resistant. Some hybrid elm species have been developed that are moderately resistant and can be utilized as replacements for American elm. Sanitation of diseased elms, and disruption of root grafts should be implemented wherever

feasible. DED affected trees should be removed the year they die to avoid emergence of bark beetles. Therapeutic fungicide injections when less than 5 percent of the total crown is exhibiting symptoms, and protective injections with three times the standard rate of Arbotect 20 S can aid in Dutch elm disease management.

Elm Phloem Necrosis Mycoplasmalike organism

American Elm

Symptoms: Drooping, yellow and green leaves develop over much of the crown in a period of a few weeks. Leaves turn bright yellow before wilting, drying and turning brown. Discoloration of the phloem, which is characterized by a butterscotch colored flecking or streaking on the inside of bark, is present on some branches. These branches may produce a distinct wintergreen odor.

Scouting: Foliar symptoms first appear as early as June. Damage is usually localized to individual or a few trees, although more widespread epidemics may occur.

Management: European and Asiatic elms are resistant. No other practical controls are known. Sanitation of affected trees is recommended.

Oak Wilt *Ceratocystis fagacearum*

Oak, particularly Red Oak Group

Symptoms: Wilting and browning of leaves in the upper crown followed by premature defoliation of affected and green leaves are the first symptoms of oak wilt. Leaves turn a dull, watersoaked gray-green and then brown along the outer margin. Browning progresses towards the midrib and leaf base, there is a sharp line between healthy and brown tissue on individual leaves, and usually only the top half of the leaf is affected. Eventually all leaves on the tree brown and trees in the red oak group may die within a single season. On white oaks, defoliation is rare, trees die slowly, have dead branches in the upper crown, and may survive infection. Brown streaking or discoloration in sapwood may be seen if bark is cut away.

Scouting: Oak wilt symptoms are easiest to identify and first appear in June and early July. Hot weather renders the oak wilt fungus less active and symptoms are difficult to identify later in the season. Lab culture of branches may be needed to positively identify the disease

Management: Oak wilt usually does not require management in forested situations because the disease causes minimal damage. In urban situations or small woodlots active measures are warranted. Root graft disruption between adjacent diseased and healthy oaks can slow spread. Mechanical and chemical means can be used to break root grafts. Deep girdling of trees, identified as infected during the growing season, accelerates drying and decreases chances of spread by insect vectors. Girdled trees should be removed during the dormant season. Wounding and pruning of oaks should be avoided from April 1 to July 1. Wounds made in this period should be treated with lanolin-based wound treatments or thick paint. Wood can be used from diseased trees if it is split to promote drying and tarped tightly the spring following death.

Verticillium Wilt *Verticillium spp.*

Maple, Catalpa, Redbud, Ash, and other Hardwood Species

Symptoms: Wilting, browning and death of leaves on individual branches or sections of a tree are typical of Verticillium wilt. The wilt fungus is also often involved in the slow decline of maple and other hardwoods. Reduced growth rate, twig or branch tip dieback, sparse crowns, and overall poor vigor can be associated with infection. A green vascular discoloration occurs in xylem of infected maples; discoloration is brown in most other species; and ash exhibits no streaking. Vascular discoloration may be present in small diameter branches, or may only be found in localized areas of large stems and roots. Ash infected with Verticillium wilt exhibit a foliar scorch and premature leaf drop.

Scouting: Symptoms of Verticillium can develop whenever foliage is present on trees, although new infection usually appear in early summer. Identifying the disease on dying trees is important because it influences choices of replacement species for the site.

Management: Use wilt resistant species, such as oaks, where Verticillium has occurred. Fertilization and good cultural practices can improve vigor and allow trees to recover from mild infections. Pruning tools should be disinfected between cuts on affected trees. Water infected trees heavily during periods of heavy evapotranspiration.

Ganoderma Root and Butt Rot *Ganoderma lucidum*

Honeylocust, Oak, Redbud, Hackberry and other Hardwoods

Symptoms: Dieback of small and large branches, undersized foliage, sparse crowns and other symptoms of root rot disease such as reduced growth rate and poor vigor are typical of Ganoderma root rot. The symptoms alone are difficult to distinguish from other stress-related maladies of

urban trees. Honeylocust may be killed quickly by the root disease.

Scouting: Diagnosis of the disease is based on identification of conks or fruiting bodies that develop at the base of infected trees in late summer-early fall (old conks may be seen year-round). The fruiting bodies are leathery, semi-circular (if attached to the base of a tree) to circular (if attached to buried root or stump) shaped, up to a foot across, and with or without a stalk. A key identifying feature is the varnished red to mahogany color of the upper surface of the conk. The conk is usually edged in white and the underside of the fruiting body is also white.

Management: Once a tree is affected, reducing stress on the tree may prolong the life of the tree. Managing the disease is accomplished by avoiding wounds. This means mulching to protect the lower stems from equipment, using tree wraps early in the life of the tree, pruning at proper times and using proper techniques, and placing trees correctly in the landscape to avoid confrontation with cars and humans.

Maple Decline
Complex of abiotic and biotic factors

Sugar Maple, Red Maple and Norway Maple

Symptoms: Maple decline is a slow loss of vigor, and general dieback of maples growing in urban environments in Missouri. Branch dieback begins with small branches, usually in the upper portion or on one side of the crown of the tree. As the decline progresses, leaves become tufted on branch tips and/or affected parts of the crown have undersized leaves on scattered branches, giving the crown an open appearance. Premature fall coloration is common and may be the first symptom of decline. Girdling roots, cankers, insect borers, verticillium wilt and frost cracks are often evident on declining trees.

Scouting: Maple decline is mainly a problem on older maples. Initial symptoms (small branch dieback, premature fall coloration) are most evident in late summer-early fall. On younger trees, scouting should focus on identifying factors that contribute to maple decline.

Management: Since multiple agents such as verticillium wilt, girdling roots, borers, canker fungi, and site conditions contribute to maple decline, treatment is difficult. Girdling roots should be severed and severely affected branches pruned. Fertilization, and watering during periods of drought may help slow the decline. Identification of individual problems contributing to the decline, and treating as many of these as possible may help improve the vigor of individual trees.

Diseases of Pines: Forest Trees

Pine Needle Rust
Ploioderma Needlecast
Littleleaf Disease
Fomes Root Rot

Pine Needle Rust
Coleosporium spp.

Shortleaf Pine and Loblolly Pine

Symptoms: Needle rust is identified by the orange to salmon colored blisters that protude from one year and older needles.

Scouting: Rust pustules are most evident during May and June. The disease is most serious where goldenrod and aster are in close proximity to the pine hosts.

Management: Control of pine needle rust is usually not needed because damage to pine is minimal. Disease severity can be reduced by elminating the alternate hosts (goldenrod and aster) before late summer within at least 1000 feet of the pine planting. Young trees are most severely affected and the disease usually mitigates with age.

Ploioderma Needlecast
Ploioderma lethale

Shortleaf Pine

Symptoms: The needlecast causes a browning of last year's needles in the late spring and early summer. Initial symptoms are brown bands and spots that develop during the winter - early spring. Needles dieback from the tip as the bands turn gray-brown and girdle the needle. Fruiting bodies of *P. lethale* are easily seen since they are 0.4 to 1.4 millimeters long and develop in groups or lines in straw-gray colored areas of affected needles.

Scouting: Symptoms are most severe in lower crown and in the early summer. Severe infection may cause defoliation later in the season.

Management: Damage caused by *P. lethale* is generally not severe enough to warrant control. Fungicide sprays have not been developed to control the disease.

Littleleaf Disease
Complex of abiotic and biotic factors

Shortleaf Pine

Symptoms: Littleleaf refers to the reduced needle length on affected shortleaf pines. Needles eventually turn off-color yellow, and become tufted at branch tips. As the decline progresses, needles brown, and tree death occurs. Littleleaf usually develops in older stands (20-plus years of age) as scattered trees. Pockets of dying trees are less common with this disease. Bark beetle attack often occurs on declining trees and hastens death. Growth reduction is significant as needle length and retention are reduced.

Scouting: Littleleaf symptoms can be observed year-round. Littleleaf should not be confused with tree death caused by Fomes root rot. Identification of high risk sites is important in diagnosis and management (see below).

Management: Littleleaf is managed by identifying high risk sites and avoiding the use of shortleaf pine on these sites. High risk sites are those exhibiting severe erosion, poor internal drainage, a zone of reduced permeability at 12 or less inches and strong mottling (grays and browns). Field rating scales have been developed to assess sites for littleleaf disease risk. Stands with existing infection should have high-risk and declining trees removed, could be thinned to improve stand vigor, and manipulated to change species composition. Fertilization, if practical, can help improve the condition of littleleaf affected trees.

Fomes Root Rot
Heterobasidion annosum

Shortleaf, Loblolly, and other pines, and Red Cedar

Symptoms: Suppressed growth, sparse crowns, often with tufted foliage at branch tips, windthrow and death are commonly associated with Fomes root rot. Growth reduction in pine plantations without significant above ground symptoms is a subtle, common and important Fomes root rot symptom. Roots infected with *H. annosum* are resin soaked and in the later stages develop a white-stringy decay that may also contain white pockets of decay. In severe cases, pockets of affected trees die, with dying trees appearing on the edge of the pocket and dead trees in the center.

Scouting: *H. annosum* conks that develop on dead and dying trees, and stumps and other slash are useful in diagnosis. Conks are frequently buried in the duff, are often small (2 to 5 cm diameter), leathery, and have a brown upper surface with a white margin. The pore surface is white and may be all that develops on some trees. Pores are uniformily shaped and small (2 to 4 per millimeters). New conks are most easily found in the fall, but the fungus can be found fruiting year round.

Management: Fomes root rot is managed by identifying high hazard sites and treating them appropriately. High hazard sites are sandy to sandy loam soils. Most sites in Missouri do not fall into this category. High hazard sites that are scheduled to be thinned and have no apparent infection should have stumps treated with borax or the competator fungus *Phelbia gigantea* immediately after felling a tree. Stands to be thinned with apparent root rot should only be treated with *P. gigantea*. Thinning in summer is helpful since *H. annosum* activity is low. All stumps should be treated in recreational areas.

Diseases of Deciduous Species: Forest Trees

Ash Yellows
Oak Decline
Armillaria Root Rot
Fusarium Canker

Ash Yellows
Mycoplasmalike organisms (MLO)

White Ash and Green Ash

Symptoms: Reduced growth rate evidenced by negligible twig growth, witches'-brooms, deliquescent branching (where branches have lost apical dominance), "frost" cracks at base of trees, chlorotic crowns, branch dieback, and death can be found on ash yellows infected trees, although all symptoms may not occur together. Groups of white ash often exhibit varying degrees of decline, and many may be in advanced stages of dieback.

Scouting: Witches'-brooms, which usually form at or near the base of trees, are most diagnostic but develop on a low percentage of yellows infected ash. Green ash is tolerant of the disease. Positive diagnosis is based on microscopic examination of root or other infected tissues for MLO's in phloem. Presence of the disease in urban trees has yet to be established.

Management: None are known. Tetracycline may give remission of symptoms.

Oak Decline
Complex of biotic and abiotic factors

All Oak Species

Symptoms: Two types of symptoms are observed in oak decline areas. The first is where the entire crown of the tree rapidly turns orange-brown and the tree dies. These symptoms usually first appear in late-July on scattered trees in a stand. The second type of symptoms are typical of a gradual decline in vigor and invasion by secondary agents. Affected trees first exhibit small branch dieback in the upper crown, with time large branches die and trees take on a staghead appearance. Numerous sucker or epicormic sprouts develop along the main stems, often giving trees the appearance of recovering. Sparsely foliated and chlorotic crowns often occur with the above groups of symptoms.

Scouting: Red oak group oaks, mainly scarlet, black and red, are the most commonly affected. Oak decline symptoms are best observed during August and late September when trees that have died quickly are evident, and branch dieback is at full expression for the year. Trees should be checked for presence of Armillaria root rot, hypoxylon canker (see other oak diseases) and two-lined chestnut borer.

Management: Management guidelines have not been fully developed. Sites that are droughty, (ridge tops and south-west facing slopes), with high component of red oak group oaks, low site index (less than 65), and nearing maturity (site index = age?), are most susceptible to oak decline. Manipulating stands to reduce red oak group component, improving stand vigor through stand improvement tactics, or converting the stand to pine after cutting are general alternatives. Thinning stands with some oak decline present may increase the progression of the disease.

Armillaria Root Rot
Armillaria mellea and allies

Hardwoods, Conifers and Shrub Species

Symptoms: The *Armillaria* fungus infects the bark and cambium of a wide range of forest and shade trees, and shrubs. After root infection, slow dieback of branches, reduced growth rate, undersized foliage and poor vigor, and eventual death occurs. Some trees and shrubs may die quickly after infection particularly during periods of tree stress. Armillaria infection centers may develop as the fungus spreads from stumps or other food sources to adjacent trees.

Scouting: *Armillaria* mushrooms typically develop in autumn from dead stumps or trees and can tentatively be identified by (1) tan to brown (honey colored) caps, (2) cespitose (several stems arising close together but not joined) clusters on wood (3) the presence of a ring around the stipe or stem and (4) white spore print (often seen on caps of overlapping mushrooms or vegetation below the fruiting body). Two other features help diagnosis on dying plants. These are the presence of mycelial fans (a felt of dense, white fungal growth) under the bark at the root collar and rhizomorphs or "shoestrings" that are a flattened black (with a white core) net-like structure that develop on roots and under bark on affected trees. Rhizomorphs snap when broken next to ones ear.

Management: Problems with Armillaria usually develop when the susceptibility of plants is increased by periods of stress. Removal of stumps and large roots can help slow short distance spread of the fungus.

Fusarium Canker
Fusarium solani

Black Walnut

Symptoms: Elongate cankers (often 2- to 3-plus feet in length), usually at or near the base of the tree, is typical of the disease. The cankers often have an exposed face (no bark) and well defined callus ridge at their margins. Insect borers commonly attack the open face of the cankers. Basal sprouts develop below the lower edge or at the base of the affected stem. Branch cankers occur, but much less frequently than basal stem infections.

Scouting: Cankers can be found anytime of year, but are usually easiest to find during the dormant season when

vegetation around trees is minimal. The disease is confined mainly to plantations.

Management: Fusarium canker is best managed by avoidance of wounding walnut during the growing season. Pruning should be done during dormancy using natural target pruning techniques, and branches should be removed from the site. Severely affected trees should also be eliminated from the plantation.

Abiotic Damage to Trees

Herbicide Injury
Winter Injury
Heat and Drought Stress

Herbicide Injury

All Trees

Herbicide injury symptoms vary greatly with the type of herbicide used and the plant species the herbicide has contacted. Generally, symptoms of herbicide injury are not diagnostic, except possibly for phenoxy-type herbicides (24-D, MCPP) and dicamba. These herbicides cause cupping, strapping, twisting and other growth abnormalities of leaves and shoots.

When herbicide injury is suspected an attempt should be made to determine the chemical that damaged the plant, and if the symptoms are consistent with the chemical used. Consult an individual familiar with herbicides or the chemicals manufacturer for specific information. Identification of herbicide residues in soil or plant tissues is very expensive, and usually can only be conducted if a single chemical is being screened for. Most labs will not do a general test for unidentified herbicides.

Some evidence that herbicides are involved might include (1) that recent, documentable applications of weed control chemicals were made in the area (2) a number of unrelated plants in the area are exhibiting similar symptoms not characteristic of insect or diseases of those plants (3) there is damage to grass or other plants along fences, sidewalks, patios, driveway, etc., where chemicals have been used to eliminate encroaching vegetation, and tree roots likely penetrate these areas (4) "bleeding out" of damage to adjacent turf from treated stumps or around other undesirable plants (5) weed free zones in areas where tree roots are likely to penetrate and (6) sensitive species, such as boxelder, redbud, siberian elm or grape are showing symptoms. More than one piece of evidence should be gathered before a herbicide injury diagnosis is made.

Treatment of herbicide damage is often difficult. In some cases, such as with light injury caused by phenoxy-type herbicides, damage to the tree may not be permanent. Stress from drought or poor growing conditions tends to increase the severity of injury. Soil replacement or ammending with materials such as activated charcoal is possible, but probably not practical on a large scale.

Winter Injury

Evergreen Species

Symptoms of winter injury on conifers typically appear when temperatures begin to warm in late winter. Browning of needles, which is usually most severe on youngest tissues, and on the south and west side of a tree, are characteristic of winter injury. Trees growing in exposed locations, on poor sites or with limited root systems are most prone to injury. Winter desiccation is often most severe when periods of drought during the growing season and fall are followed by cold, open winters.

Winter injury is best avoided by keeping conifers well mulched and watered into the fall, avoiding using winter injury prone species in open, exposed locations or planting on poor sites (excessively wet or dry), and providing protection to young or newly planted stock. Anti-desiccant sprays to protect trees are not recommended.

Heat and Drought Stress

Symptoms such as marginal browning of foliage, wilting of leaves, premature leaf browning and drop, reduced growth and branch dieback on deciduous species; and on conifers, needle tip browning, browning of entire needles, and branch dieback, develop when trees are under drought and heat stress. These symptoms generally follow periods of extreme heat or drought, but can occur under normal conditions on trees with root damage, limited available rooting space or growing on extremely compacted soils.

Drought and heat stress generally increase the overall susceptibility of a tree to invasion of secondary insects and diseases. Established trees are seldom killed directly by the drought.

Mulching is extremely important in reducing drought stress, by conserving water and promoting good root growth. Watering during periods of drought is useful, if local regulations permit. The equivalent of 1 inch of rain per week, every two weeks, should be used. More frequent waterings should be made on newly planted trees.

Annual Pest Occurence Calendar

March

Insects

Pales weevil—be aware of presence on Scotch pine in south Missouri

Diseases

Browning of shoot tips on *Juniperus* spp. caused by Kabatina tip blight

Browning and death of entire Scotch and Austrian pines due to pine wilt disease

Browning of needles on evergreens as a result of winter injury

April

Insects

Pales weevil—be aware of presence on Scotch pine in central and north Missouri

Eastern Tent Caterpillar—look for webbing and defoliation by midmonth on black cherry and flowering crab trees

European Pine Sawfly—look for tiny larvae by midmonth on Scotch and mugo pines

Bud mining of walnut and hickory, (Acrobasis) begin to note holes in buds and growth of these trees.

Looper Complex—begin observing defoliation of mixed hardwoods by this complex of insects by late April.

Diseases

Orange tenacles develop from cedar-apple rust galls on *Juniperus spp.*

Spotting, banding and defoliation of needles of Scotch pine caused by Lophodermium needlecast

Time to spray for Diplodia tip blight of Austrian pine

May

Insects

Gall forming insects—begin noticing galls on leaves and stems of various hardwoods. On hackberry oak and hickory species-most notably

Loblolly pine sawfly—begin noticing defoliation of planted shortleaf pine trees by May 5 in central Missouri.

Hardwood borers—begin spraying susceptible tree trunks by May 25—spray two weeks later, than finally in two more weeks spray a third time

Diseases

Cedar-apple rust orange and yellow spots on leaves of hawthorne and crabapple

Pine-needle rust on shortleaf and loblolly pines

Apple scab on crabapple appears as olive-brown leaf lesions

Sparse crowns on sycamores due to sycamore anthracnose

Maple & ash anthracnose symptoms first appear

Oak leaf blister causing yellow-green blistered areas on oak leaves

Frost damage earlier in the season resulting in bare crowns, particularly in low pockets in the Ozark region

Time to spray for brown spot on Scotch pine when needles are one-half elongated. Spray again when needles are fully elongated.

June

Insects

Evergreen Bagworm—begin looking for tiny bags on foliage around June 15

Gouty vein gall midge will begin appearing on veins of suger maple and pin oak. Two different species of midge are involved

Redheaded Pine Sawfly—observe tiny larvae on needles of shortleaf pine. Possibility of three generations per summer

Datana defoliation can be observed on walnut, pecan, hickory, oaks and sumac by months' end

Spider mite damage may begin in mid to late June and continue until first frost. Possibility of eight generations per year

June Beetles—appearance of adult beetles feeding on assorted hardwood foliage

Nantucket pine tip moth—observe development of first generation on Scotch and shortleaf sapling size pine

Diseases

Oak wilt symptoms first appear on red oak group oak

Dutch elm disease causing flagging of branches on American elm

Phomopsis blight on *Juniperus spp.* causing dieback of new shoot tips

Verticillium wilt on maple, catalpa, redbud and other hardwoods causing wilting and dying of branches

Fire blight strikes appear on crabapple, pear, apple, cotoneaster and other rose family hosts

New tip dieback on Austrian and Scotch pine from Diplodia tip blight

July

Insects

Fall webworm—notice forming of webs on persimmon, walnut, pecan hickory and sycamore

Spider mite damage continues on spruce, Scotch pine and baldcypress

White pine aphid activity on bark of white pine

Evergreen Bagworm—observe continued feeding on ornamental evergreens and eastern redcedar

Datana Caterpillars—observe continuation of feeding on species listed for June

Nantucket pine tip moth—development of and generation of pine species

Stinging Insects—note presence of yellow jackets, bald faced hornets and cicada killer wasps during very hot and dry summers

Diseases

Rhizosphaera needlecast, on blue spruce causing browning of older needles

Branch dieback on blue spruce due to Cytospora canker

Ozone injury causing browning on new needles tips on white pine

Iron chlorosis readily apparent on pin oaks

Ooze or slime flux evident on wetwood infected elms, mulberry's and cottonwoods

Rust appears on ash infected with ash rust and cottonwoods infected with Melampsora rust

August

Insects

Nantucket pine tip moth—observe development of third generation and damage on sapling size Scotch and shortleaf pines

Twig Girdler—observe twig girdling on persimmon, hickory and elm in months' end

Diseases

New symptoms of oak decline begin to appear on red oak group oaks

Yellowing and premature drop on black walnut leaves caused by walnut anthracnose

Yellowing and premature drop of leaves on crabapple due to apple scab

Powdery mildew evident on many hardwood species

Actinopelte leaf spot causing browing of leaves on pin and other oaks

Heat and drought-stress symptoms appear as a marginal browning on many hardwoods

Ash yellows symptoms peak on white ash

September

Insects

Boxelder bugs—note swarming around structures to overwinter

Elm Leaf Beetles—observe swarming around structures to overwinter

Diseases

New dying of Scotch pine due to pine wilt disease

Spotting and banding on current year needles of Scotch pine due to brown spot needle blight

Needle banding and browning on new needles of Austrian pine caused by Dothistroma needle blight

Seasonal needle yellowing and drop evident on many conifers

Ganoderma fruiting bodies (conks) present at the base of many hardwood such as honeylocust and oak

Premature fall coloration on maple and other hardwoods indicate the tree is stressed or in a state of decline

Cyclaneusma needlecast causing yellowing of inner needles on Scotch and other pines

October

Insects

Boxelder Bugs—swarming and seeking shelter

Elm Leaf Beetle—seeking shelter

Diseases

Fruiting bodies of wood decay fungi present on many trees indicating wood decay is present

Seasonal needle yellowing a drop continues on many conifers

Minor Insects on Selected Tree Groups

Basswood—Lace bug

Eastern Cottonwood—Leaf galls, poplar twig borer, cottonwood twig borer, cottonwood root and stem borer, aspen borer, cottonwood leaf beetle, June beetle, cottonwood dagger moth, poplar tentmaker, leaf hoppers

European white birch—Bronze birch borer

Hackberry—Miscellaneous leaf and twig galls, witches broom, hackberry butterfly (defoliator)

Hickory—Twig pruner, miscellaneous leaf and twig galls, hickory tussock moth

Honeylocust and varieties—Plant bug, clay-colored leaf beetle, June beetle

Maple—Maple bladder gall mite (silver maple) gouty vein gall midge (hard maple)

Oak—Orange-striped oak worm, red humped oak worm, variable oak leaf caterpillar, oak slug sawfly (pin oak) gouty vein gall midge (pin oak), other various leaf galls, including pill gall, two-lined chestnut borer (secondary)

Ohio Buckeye—Lace bug

Pine—Pales weevil (Scotch and shortleaf pine), pine webworm (Scotch and shortleaf) pine needle midge (shortleaf)

River Birch—River birch sawfly

Serviceberry—Lace bugs

Minor Diseases by Host
(Records for Missouri)

Conifers and Evergreens

Host	Disease	Cause
Eastern Red cedar Rocky Mountain juniper	Cercospora blight	*Cercospora sequoiae* var *juniperi*
Scotch pine	Brown spot	*Scirrhia acicola*
	Lophodermium needlecast	*Lophodermium seditiosum*
	Cyclaneusma needlecast	*Cyclaneusma minus*
Shortleaf pine	Comandra rust	*Cronartium comandrae*
	Eastern gall rust	*Cronartium quercuum*
Spruce	Sirococcus shoot blight	*Sirococcus strobilinus*

Decidious Species

Host	Disease	Cause
Cottonwoods and Poplars	Marssonina leaf spot	*Marssonina brunnea*
	Septoria leaf spot and canker	*Mycosphaerella populorum*
	Melampsora rust	*Melampsora medusae*
	Cytospora canker	*Valsa (Cytospora) sordida*
	Crown gall	*Agrobacterium tumefaciens*
Maples	Tar spot	*Rhytisma acerinum*
	Phyllosticta leaf spot	*Phyllosticta minima*
	Stegonosporium canker	*Stegonosporium spp.*
	Valsa canker	*Valsa (Cytospora) spp.*
Elm	Black spot	*Stegophore ulmea*
Hickory	Leaf spot	*Gnomonia caryae*
Hackberry	Witches' broom	undetermined
Cherry and other *Prunus spp.*	Crown gall	*Agrobacterium tumefaciens*
	Black knot	*Apiosporina morbosa*
Russian olive	Phomopsis canker	*Phomopsis arnoldiae*
	Tubercularia canker	*Tubercularia ulmea*
Ash	Mycosphaerella leaf spot	*Mycosphaerella effigurata*
	Phyllosticta leaf spot	*M. Fraxinicola*
Oak	Strumella canker	*Urnula craterium*
Dogwood	Collar rot	*Phytophthora spp.*
	Leaf spot	*Septoria spp.*
Walnut	Mycosphaerella leaf spot	*Mycosphaerella juglandis*
	Microstroma White mold	*Microstroma julandis*
	Bunch Disease	mycoplasma-like organisms
Pecan	Scab	*Cladosporium effusum*
Willow	Cytospora canker	*Cytospora chrysosperma*

Beneficial Organisms Associated with Insect Epidemics

There are various natural biological controls of insect pests. We rely on these organisms to control our native insect pests which result in insect population fluctuations.

Listed are some beneficial organisms which control native insect populations. It might take two, three or four years for the beneficial organisms to build to such large numbers that they become effective in controlling damaging insects.

Beneficial Organisms	Insect Pest
1. Fiery Caterpillar Hunter a. *Calosoma scrutator* (F.) ground beetle b. Egg Parasites c. Predaceous Bugs	Looper Complex
2. Lady Beetles larvae and adults	Soft bodied insects such as aphids and scale insects and spider mites
3. *Telenomous* Wasp egg parasite	Variable Oak Leaf Caterpillar
4. Baculovirus	Variable Oak Leaf Caterpillar
5. Praying Mantid	Predator of variety of insects
6. Wheel Bug *Arilus cristatus*	Predator of variety of insects
7. *Bacillus thuringiensis* (Berliner) is a biological insecticide. Various chemical companies have developed commercial formulations. One is Dipel, the second is Thuricide. Material must be sprayed on leaf or needle surface and must be ingested by damaging larvae to be effective.	A bacteria used to control leaf feeding insects in the order Lepidoptera. (Moths and butterflies) used against larvae feeding on agricultural crops and ornamental trees and shrubs.

References for Identification of Tree Diseases

A complete reference library is essential to diagnosing tree problems. Very few individuals can remember and recognize all the insect, disease and abiotic injuries for the wide range tree and shrub species that call Missouri home, without some additional guidance. It is *not* necessary to buy every book listed below. A few well chosen references, that cover the major tree species, and both insect and disease problems, should suffice to start. Most individuals find that as the need for more in-depth diagnosis arises so does the need for a more extensive library. Consult with a person who regularly diagnoses tree problems for recommendations on the most helpful and commonly used references.

One of the best sources of information on specific tree problems, chemicals labeled for insect and disease control, and identification and control of symptoms, are fact sheets and control guides distributed by the Conservation Department and University Extension. Fact sheets prepared by states other than Missouri can be useful if the specific information cannot be obtained in state.

Finally, insect and disease problems are very dynamic. The most efficient way to keep abreast of new problems, seasonal outbreaks, changes in pesticide labels, development of new cultivars, and new research results is by subscribing to newsletters published by the Conservation Department, University Extension or private organizations. Often, obtaining more than one newsletter will give the best coverage of a wide range of problems. Pest management personnel in the Conservation Department put out an Insect and Disease Status Report monthly from April–September. It can be obtained by writing the Forestry Division.

TEXTBOOKS AND REFERENCES

Tree Disease Publications

Fosberg, J.L. 1975. *Disease of Ornamental Plants.* Third Edition. University of Illinois Press.

Pirone, P.P. 1978. *Diseases and Pests of Ornamental Plants.* Wiley-Interscience.

Tattar, T.A. 1989. *Disease of Shade Trees.* (Revised). Academic Press.

Westcott, C. 1979. *Westcott's Plant Disease Handbook.* Fourth Edition. Revised by R. Kenneth Horst. Van Nostrand Reinhold Co.

Manion, P.D. 1981. *Tree Disease Concepts.* Prentice-Hall Inc., Englewood Cliffs.

Blanchard, R.O. and T.A. Tattar. 1981. *Field and Laboratory Guide to Tree Pathology.* Academic Press.

Sinclair, W.A., H.H. Lyon and W.T. Johnson. 1987. *Diseases of Trees and Shrubs.* Cornell University Press.

Farr, D.F., G.F. Bills, G.P. Chamuris, and A.Y. Rossman. 1989. *Fungi on Plants and Plant Products in the United States.* American Phytopathological Society, St. Paul, MN.

Tree Insect Publications

Johnson, W.T. and H.H. Lyon. 1988. *Insects that Feed on Trees and Shrubs.* Second Edition. Comstock Publishing Associates, Cornell Press. Ithaca, NY.

Extension Entomologists. 1989. *Insect Control Recommendations.* University of Missouri Cooperative Extension Service. Columbia, MO (Updated annually).

USDA MANUALS

Tree Disease Publications

Hepting, G.H. 1971. *Diseases of Forest and Shade Trees of the United States.* Ag. Handbook No. 386.

Peterson, G.W. and R. S. Smith, Jr. 1975. *Forest Nursery Diseases.* Ag. Handbook No. 470

USDA. 1979. *A Guide to Common Insects and Diseases of Forest Trees in the Northeastern United States.* Northeastern Area, State and Private Forestry. Publ. NA-FR-4.

Peterson, G.W. 1981. *Pine and Juniper Diseases in the Great Plains.* USDA Forest Service. Gen. Tech. Report RM-86.

USDA Forest Service. 1983. *Christmas Tree Pest Manual.* J.M. Benyus, ed. North Central Forest Experiment Station.

Riffle, J.W., Peterson, Glenn Tech. coords. *Diseases of Trees in the Great Plains.* Gen. Tech. Rep. RM-129. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Tree Insect Publications

USDA Forest Service. 1985. Insects of Eastern Forests. Miscellaneous Publication No. 1426.

NOTE: USDA Manuals are for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (202) 783-3238.